ASTRONOMY

September 1993 U.S. $2.95
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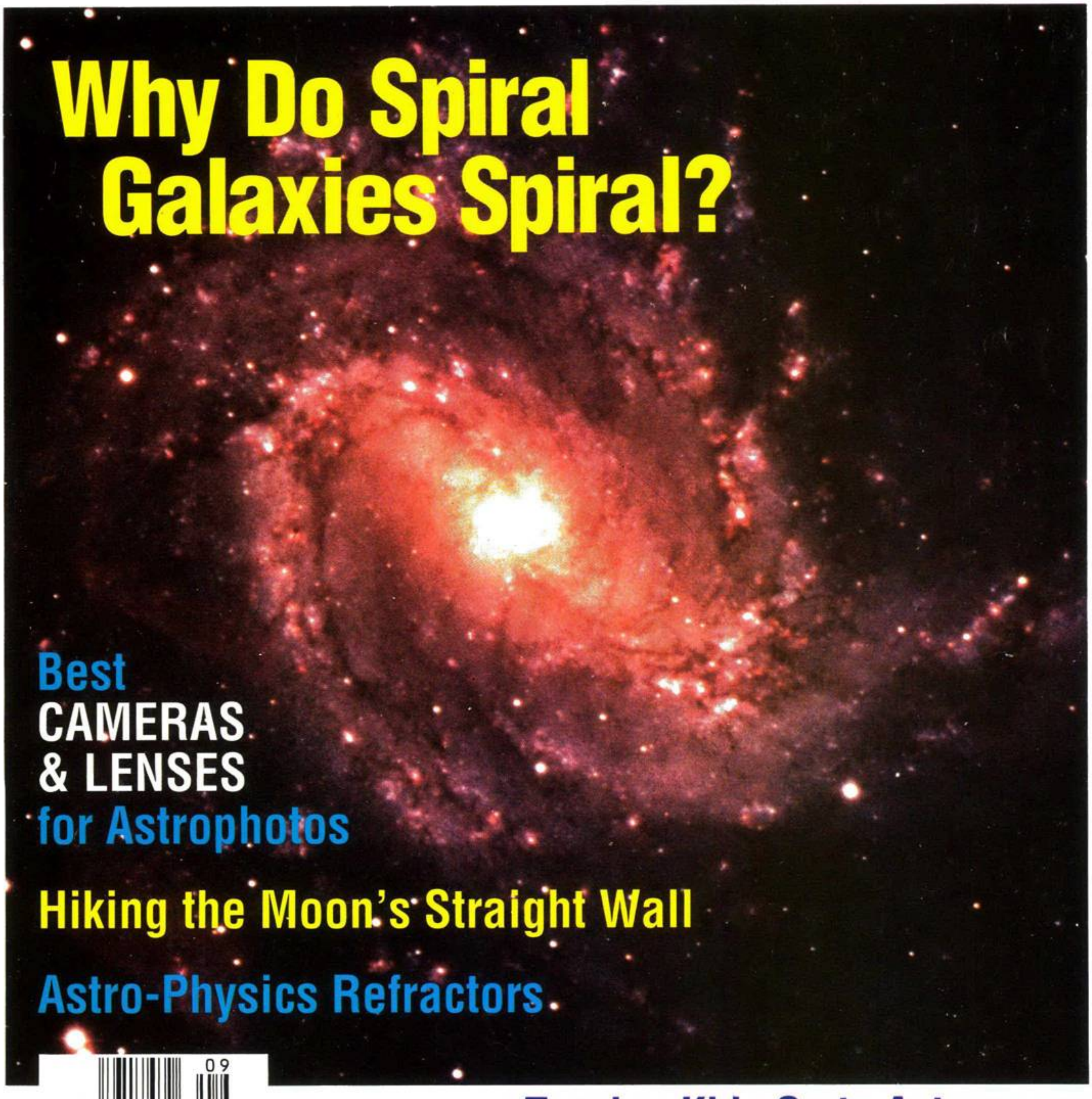
MARS: DID IT ONCE HAVE LIFE?



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Superwedge 10"	**395.**
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■*All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

■For dealer or catalog information see the Meade **ED Apochromatic Refractor** ad in this issue.

Meade 10" LX200. Shown with optional Superwedge.

Meade 8" LX200. All features shown are standard equipment.

LX200 SCHMIDT-CASSEGRAINS

The largest-selling serious telescopes in the world.

Now you can buy the most advanced 8" and 10" Schmidt-Cassegrains ever produced, at a price directly competitive with other SCT's offering only a fraction of the features!

Meade LX200 SCT's offer a revolutionary departure from any other SCT's ever made available. Consider the **standard specifications** of these telescopes:

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100% Computer-Controlled Operation—All-new Meade LX200 microprocessor-controlled drive systems offer an incredible array of features:

■**Four-speed operation on both telescope axes** simultaneously, including (a) photo-guiding (at **2x** sidereal rate); (b) image centering and microslewing in the main telescope (at **32x** sidereal rate); (c) image centering in the view-finder (at **2**° per sec.); or fast-slew of the main telescope across the skies (at **8**° per sec.).

■**Pushbutton Electric Slew**—Press RA or Dec slew, east or west, north or south, and the telescope moves at 8° per sec. on both axes. As you near a desired object, flip to 2° per sec. slew, to center the object in the field. The observer need never touch the telescope in moving from one object to another. (Of course, if you wish, the telescope may be moved manually as well.)

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LX QUARTZ – DC SERVO MOTOR
SMART DRIVE
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Encoders
RS232
Focuser
Reticle
Keypad
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CCD

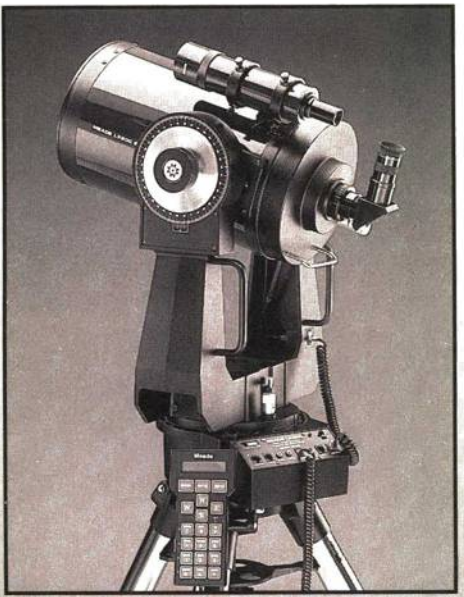
■**Digital Readouts** on both axes, read from the handheld Electronic Command Center (ECC).

■**GO TO Capability**—Enter the RA and Dec of an object into the keypad of the ECC, press GO TO, and the telescope automatically slews to the object at 8° per sec., centering it in the field.

■**747-Object Built-in Library**—Enter any of the 110 Messier objects, 278 of the finest NGC objects, 351 stars (doubles, variables, polar reference stars), or one of the 8 planets, from Mercury to Pluto, press GO TO, and the telescope slews at 8° per sec. to the object with uncanny precision. For $99* add the 8000-object Meade CNGC library, a 30-second plug-in.

■**Permanently programmable (PPEC) Smart Drive**™, capable of reducing periodic drive errors to 5 arc. sec. or less.

Legendary Meade Super Multi-Coated f/6.3 or f/10 Schmidt-Cassegrain Optics—Now you can choose either wide-field f/6.3 or classical f/10 Meade US-made SC optics **at the same price.** Either way, you'll be buying the finest Schmidt-Cassegrain optical system available, a system that yields razor-sharp stellar images and high-resolution observing of the Moon, planets, and deep-space, from the World's leading manufacturer. Meade exclusive Super Multi-Coatings on both sides of the correcting plate assure maximum light transmission and contrast.



Altazimuth Mode Operation—For all visual observing applications, and for lunar and planetary photography, Meade LX200's may be set up in the altazimuth mode, without any equatorial wedge—just attach the telescope's drive base directly to the tripod, use the fast 1-star alignment procedure, and the telescope's computer actuates 2-axis tracking that keeps objects precisely centered in the field, even at high powers, during the entire observing session. For long exposure photography (longer than about 5 minutes) altazimuth-induced field rotation requires an equatorial wedge, which may be purchased separately.

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The widest array of keypad and power-panel control functions—In addition to the microprocessor-controlled operations listed above, the handheld ECC and the telescope's power panel permit: readout of sidereal or local time; actuation of the optional electric focuser; crossline brightness control of an illuminated reticle eyepiece; direct plug-in of popular CCD autoguiders/imagers; and more than 14 other telescope functions.

MEADE LX100 SCHMIDT-CASSEGRAINS

Observers not requiring the sophistication of the LX200 electronics may wish to consider an 8" or 10" LX100 model SCT instead. Meade LX100's include the exact same heavy-duty fork mounts of their LX200 counterparts, but with a microfine declination tangent arm control in place of the LX200's motorized worm gear, and with a 2-speed drive in place of the LX200's 4-speed drive; optical tubes and coatings are identical. Standard LX100 features include:

■ Handheld Electronic Command Center—With 2-speed operation, **2x** for photo-guiding and **32x** for image centering and microslewing in the main telescope. (With the optional DC-servo declination motor installed, these speeds are operational on both telescope axes.)

■ Permanently programmable (PPEC) Smart Drive, as described above.

Complete LX100 and LX200 Telescopes

Specifications: 8" and 10" LX200's—Each complete telescope includes: 8" or 10" SC optical tube assembly (specify f/6.3 or f/10) with super multi-coatings; heavy-duty fork mount, with 4" polar ball bearing, dual-axis 5.75" worm-gears, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; handheld keypad Electronic Command Center, with digital readout display, PPEC Smart Drive, four-speed drive control on both axes, GO TO controller, and 747-object software library; 25 ft. power cords for telescope operation from either 12 v. DC auto cigarette lighter plug or 115v.AC; 8 x 50mm viewfinder with crosshairs; diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece; variable-height field tripod; new deluxe die-cut-foam-fitted carrying case; complete operating instructions.

Specifications: 8" and 10" LX100's—Each complete telescope includes 8" or 10" SC optical tube assembly (specify f/6.3 or f/10) with super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, 5.75" RA worm gear, and multi-function power panel display on the drive base; manual slow-motion controls on both axes; handheld pushbutton Electronic Command Center with PPEC Smart Drive and 2-speed drive control; 25 ft. power cords for telescope operation from either 12v. DC auto cigarette lighter plug or from 115v. AC; viewfinder: 6 x 30mm (8") or 8 x 50mm (10"); diagonal prism (1.25"); Series 4000 Plössl 26mm eyepiece; variable-height field tripod; equatorial wedge (8") or Superwedge (10"); new deluxe die-cut-foam-fitted carrying case; complete operating instructions.

For the beginner, or for the most seasoned observer, Meade LX200's are the most user-friendly telescopes ever manufactured. First-time telescope users **almost uniformly** remark that "I saw **hundreds** of deep-space objects my very first night out!" Advanced amateurs report that "the LX200 found objects during my first observing session that I was unable to locate in over 20 years of serious observing with other telescopes."

Contact your authorized Meade dealer today. See for yourself why Meade LX200's are the largest-selling serious telescopes in the world.

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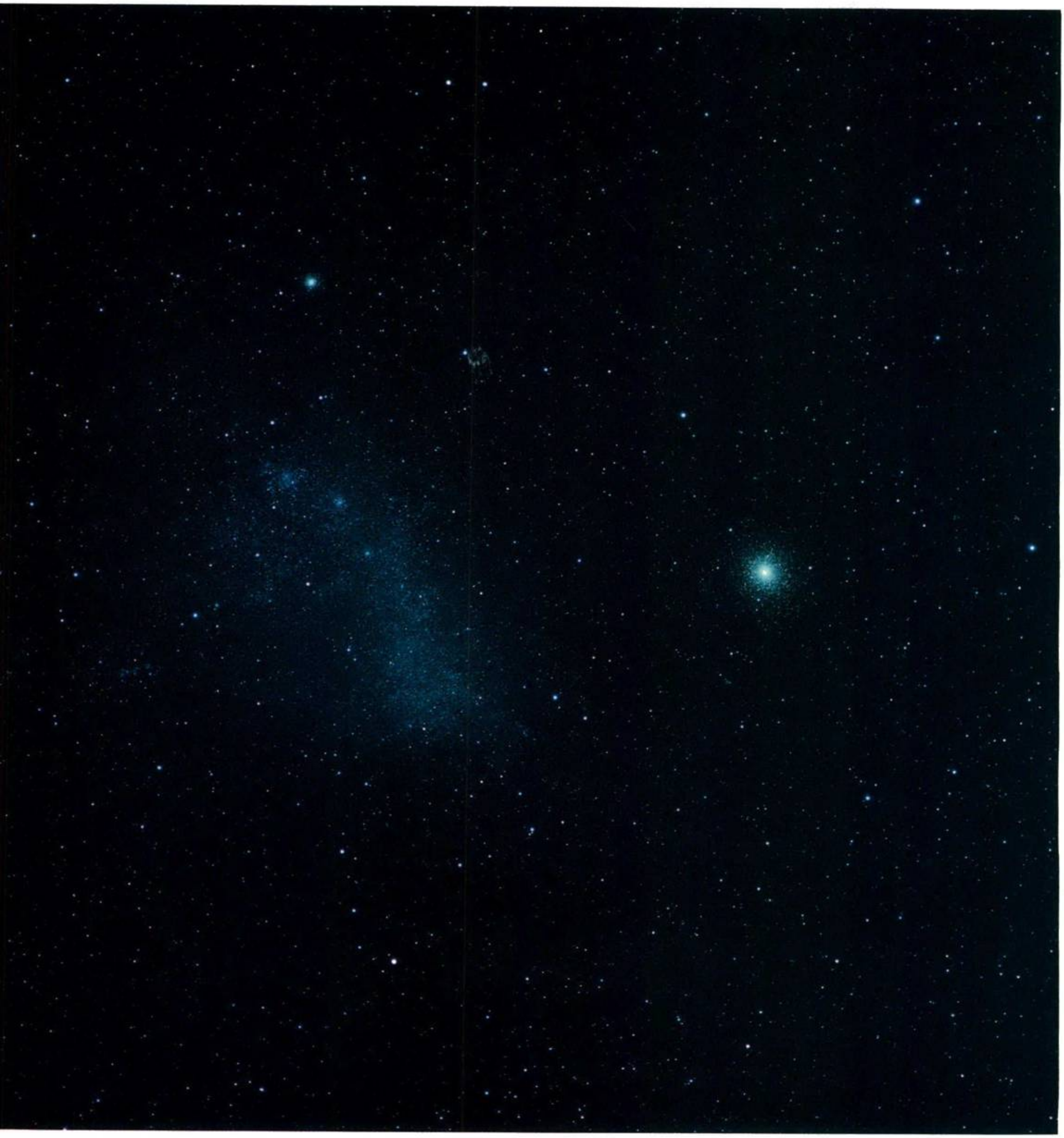
THE MAGELLANIC CLOUDS EMBODY the wonder most northerners feel when seeing the Southern Hemisphere sky. Here the Small Magellanic Cloud poses with the Milky Way's great globular cluster, 47 Tucanae, to entice viewers to head south. (See page 68 for more highlights from Down Under.)

ON THE COVER: We've all fallen for the beauty of spiral arms in galaxies like M83. Now new research shows us how these complex structures form. (See page 34.)
© 1977 Anglo-Australian Telescope Board.



Luke Dodd

20th ANNIVERSARY YEAR

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Behind the Scenes

BUILDING ASTRONOMY'S FUTURE

How do you make an astronomer? In "Building Astronomy's Future" (see page 40), associate editor Dave Bruning examines some of the clever ways teachers are bringing astronomy to students. These range from "observing sessions" that take place entirely inside a computer to putting real live data from NASA missions into the hands of students who write papers on their research results. As you read the story, I hope you'll be as impressed as I was at the variety of ideas going around.

What also struck me is that learning astronomy today has a lot more whizz-bang than most of us ever got! Unfortunately, teachers probably need it. You'd never think keeping kids interested in astronomy could be a problem. But despite the subject's obvious appeals — space, distant planets, cosmology, the Big Bang — it's not easy to get kids involved.

Maybe we backyard astronomers live too close to the subject to see it as outsiders do, or maybe it's the highly distracting environment kids grow up in — or maybe it's just hormones. Anyway, all over North America the people lucky enough to teach astronomy (and science in general) find it hard to fire kids up.

Clearly, not everyone exposed to astronomy in school will go on to become an astronomer. In fact this is a good thing because the field couldn't begin to supply jobs for all of them. And how many astronomers does society actually need, anyhow? Astronomy can't heal the sick. It doesn't grow food and it doesn't create a tangible product. For the most part it won't make you rich or famous.

Astronomy, however, does have a strong, vital recreational value for many people. (After all, that's what drew you and me to it.) But astronomy does much more. It helps all of us in society keep a sense of perspective on the big things. It encourages human beings not to think of themselves as exempt from the natural laws that run the universe.

That's great, I hear you saying, but what does it have to do with me? Well, to be blunt, the people teaching astronomy need you. Backyard astronomers like yourself can be a precious resource for schools. You and your first-hand knowledge of the heavens can turn dry classroom lessons into unforgettable experiences.

Rig your scope for safe solar viewing and let kids see the face of their star. Or pick a day around First Quarter and show them lunar craters in the afternoon. Or if it's cloudy, bring a computer and run some of that snazzy software you have. The sailing won't always be smooth. Schools may have liability problems if they bring kids back at night for star viewing, and many amateur astronomers are not available during school hours.

But even if all you can do is give a slide show for a class, that's worth doing. You'll move astronomy out of the textbook and show that it can matter to people. Remember, kids ask themselves the same Big Questions about Big Things that you do. You found a way to explore those questions — why not help a new generation do the same?

Sincerely,

Robert Burnham
Editor

ASTRONOMY

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Letters

ASTRONOMY's 20th Anniversary

Congratulations on the anniversary. Your article on where astronomy is going has raised this question in many people's minds. Lacking the gift of divination, I'll try a bit of extrapolation. Although I am a producer of printed almanacs, I expect to see computer programs and databases increasingly replace printed material. The annual *Astronomical Almanac* — the printed standard for astronomical calculations — will give way to user-friendly programs that will calculate data specifically for the needs of the user. An important step toward this goal is *MICA*, a multiyear, high-precision computer almanac produced by the U. S. Naval Observatory. Twenty years from now there will still be good and bad, user-friendly and user-hostile programs, but a successor to *MICA* will surely serve as a recognized standard of reference.

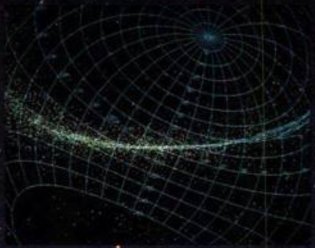
And what of ASTRONOMY, the magazine? We'll receive it electronically, for reading on the sofa, at the desk, or just about anywhere else. It will appear onscreen with all of the production quality we enjoy today on the printed page, with instantaneous access to previous volumes and other databases and with software for searching, editing, and communicating. I look forward to enjoying the electronic ASTRONOMY on the sofa, with my feet on the coffee table. Will we really have Volume 41 this way? Only if we get our feet off the coffee table and get to work. — *LeRoy E. Doggett, chief, Nautical Almanac Office, U. S. Naval Observatory, Washington, D.C.*

Astronomy has advanced more rapidly over the past twenty years than at any time in history. The next twenty years will undoubtedly bring more new discoveries, but I suspect the pace will slacken somewhat. We all know that progress in astronomy is driven by the instrumentation we have at our disposal. This last decade has seen the advent of many new instruments — IRAS, COBE, GRO, and infrared detectors from ground and space, to name a few. Observations from these instruments have changed our view of the universe. Everywhere we have looked we have uncovered completely unexpected phenomena that have challenged our ideas.

I don't see how we can expect to keep up the pace. Budgetary limitations, for one, will slow the pace of new instrumentation. Golden knowledge will still flow but perhaps more slowly. The field does hold magnificent promise. And we

[continued on page 12]

ALTER FOREVER YOUR SENSE OF SPACE AND TIME



Flowing time and motion brings life to the sky and solar system.
Through the power of gravitational simulation, break your bounds to the present. Seasonal motions, retrograde epicycles, comet and planet apparitions, eclipses, occultations, conjunctions... ephemeral events, all a pleasure to watch in the natural flow of time.

Go *beyond* the calculable to find orbital precession, resonance, and chaos. See where asteroids and comets are at any time; study the satellite and ring systems. Learn how Jupiter keeps things stirred up. Find lost comets, and witness future orbit-changing encounters. And of course enjoy a beautiful, starry sky, from space or Earth, with constellations and deep sky objects.

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Accompanied by an acclaimed manual and tutorial tours of the sky and solar system, *Dance of the Planets* has become the standard wherever there is abiding interest in astronomy.

Rated *Best Overall Package* and *Editors Choice*, **Astronomy Now** (UK) review of thirteen astronomy software packages, August 1992

Finalist, **Discover** Magazine's *1992 Awards for Technological Innovation*

Richard Berry, **Astronomy** Editor in Chief, August 1991... "most imaginative and imagination–inspiring software I have yet seen running on a PC..."

John Mosley, **Sky & Telescope** June 1992 review..."it remains an order of magnitude better than any other solar system simulator. It's a must have."

New *The Observer's Companion*
On-line calculating almanac finds past and future eclipses, conjunctions, occultations, risings, settings, meteor showers, lunar circumstances, and more. A welcomed companion to the powerful *Dance* simulation capabilities. *Only $30 when ordered with Dance.*

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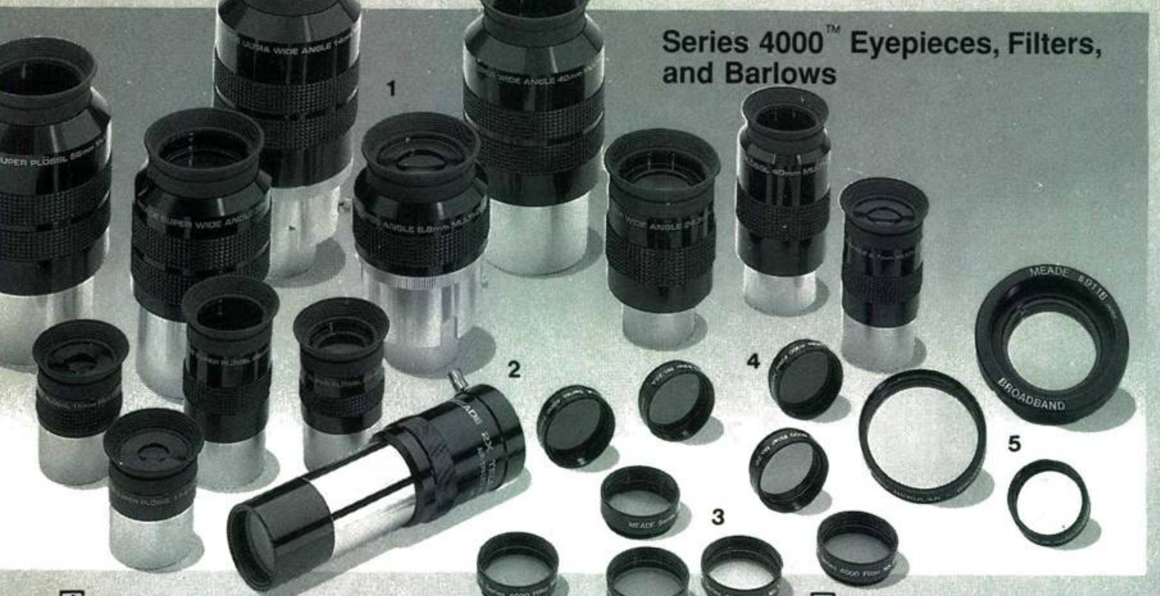

1 The World's finest telescope eyepieces now include rubber grips and soft rubber eyeguards for an even better observing experience! All eyeguards fold down for eyeglass wearers—a feature not available on competing brands. Best of all, **Meade Series 4000's are guaranteed to deliver more field, more contrast, and more image sharpness than any other brand at any price, or your money back.*** For splitting the closest doubles, revealing tenuous, faint nebulosity in deep-space, or studying hairline lunar and planetary detail, Meade multi-coated Series 4000's are the oculars that serious observers insist upon. ***"Clearly the best."***

Super Plössls (5-elements; 1.25"; 52°):
6.4; 9.7; 12.4; 15; 20; 26mm ea **$87.95** (3.29)
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56mm (52°, 2") **229.95** (4.18)

Super Wide Angles (6-elements; 1.25"; 67°):
13.8mm: **139.95** (3.29) 18mm: **149.95** (3.29)
24.5mm: **169.95** (3.79) 32mm(2"): **239.95** (4.18)
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*at participating dealers; see catalog for details.

2 **#140: Series 4000 2x Apochromatic Barlow Lens** (1.25")--The original Meade 3-element, air-spaced, multi-coated design. Absolutely unmatched in image resolution and color correction. 28mm dia. lens (26mm clear aperture). **$79.95** (3.29)

3 **Series 4000 Photo-Visual Color Filters** (1.25")—Made of purest crown optical glass, dyed in the mass. For increased contrast on the Moon and planets. Thread into virtually all 1.25" eyepieces sold today. Fully coated.

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each **$12.95** (2.29)

Set #1—4 filters: #12 Yellow, #23A Lt.Red, #58 Green, #80A Blue **$49.95** (2.79)

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5 **Series 4000 Nebular Filters**—The very latest in multi-layer interference coating technology, Meade premium nebular filters are guaranteed to be the finest obtainable at any price. Use a Series 4000 Broadband filter to block most forms of light pollution, with minimal attenuation of desired wavelengths. Use a Narrowband filter in heavily light-polluted areas, or for extremely high contrast observing of faint nebulae.

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#910B—Threads into all Meade 2" eyepieces and most others; 44mm dia. **119.95** (2.79)

#911B--Threads on to the rear cell of Schmidt-Cassegrain telescopes. **99.95** (3.29)

NARROWBAND FILTERS

#908N (1.25")—Threads into virtually all 1.25" eyepieces; 26mm clear aperture. **89.95** (2.49)

#910N—Threads into all Meade 2" eyepieces and most others; 44mm dia. **129.95** (2.79)

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The finest focusers in the industry. Meade rack and pinion mechanisms have precise, ultra-smooth action along the entire travel distance. Housings are machined for tight fit of .the moving sleeve. All focuser models may be used on tubes of from 4" to 20" diameter; all accept 1.25" eyepieces. Mounting hardware included.

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#545: 8 x 50mm-*(lower photo)* Wide 5° field; coated achromatic objective; crosshair eyepiece. White tube. Ideal for telescopes of any aperture. See bracket below. **69.95** (4.28)

#544: 8 x 50mm-- Same as #545, but in Meade blue. **69.95** (4.28)

#957: 9 x 60mm--*(top photo)* Collects 44% more light than 50mm; superior for faint objects; bracket below. **99.95** (4.68)

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Specify model desired. each **$49.95** (2.79)

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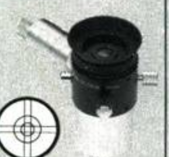
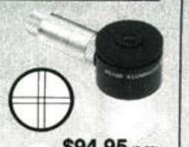


Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Internal batteries included. Multi-coated optics. Bullseye reticle. 1.25" **$129.95** (3.29)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$109.95** (3.29)

MA 12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Includes wireless red LED illuminator with internal batteries and variable brightness control. **$94.95** (3.29)

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#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter **$99.95** (3.29)

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Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-Mount, available separately.

.965": **$27.95** (2.79) 1.25": **$29.95** (2.79)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-Mount for your camera. **$39.95** (2.79)

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For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Use with T-Mount for your camera.

Basic Tele-Extender: *(above)* Fixed projection power; use with eyepiece for lunar and planetary photos. **$29.95** (2.79)

Variable Tele-Extender: Sliding cell, with lock, permits wide range of projection magnifications with the same eyepiece. **$39.95** (2.79)

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2X Telenegative Barlow (1.25")

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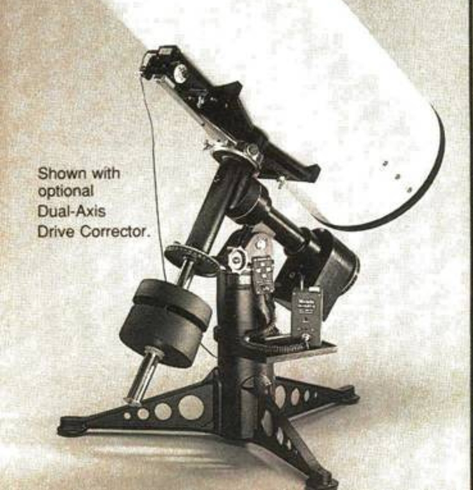
See the Meade General Catalog for details.



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A Meade Starfinder telescope opens up the skies to an extremely wide range of serious visual observing, to lunar and planetary photography, and even to limited deep-space photography. And every telescope is backed by the World's largest manufacturer of serious telescopes.

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Specifications: 8" Model 2080A—Complete with 8" f/10 Schmidt-Cassegrain optical tube assembly; fork mount with setting circles, manual slow-motion controls and locks on both axes; 5.75" worm gear motor drive system (115v./60Hz); eyepiece-holder (1.25"); diagonal prism; coated MA 25mm eyepiece (1.25"); 6 x 30mm viewfinder; equatorial wedge; variable-height all-metal field tripod. . . . . **$1099.**

Model 2080B—Identical to Model 2080A, but in addition with Super Multi-Coated optics. **$1149.**

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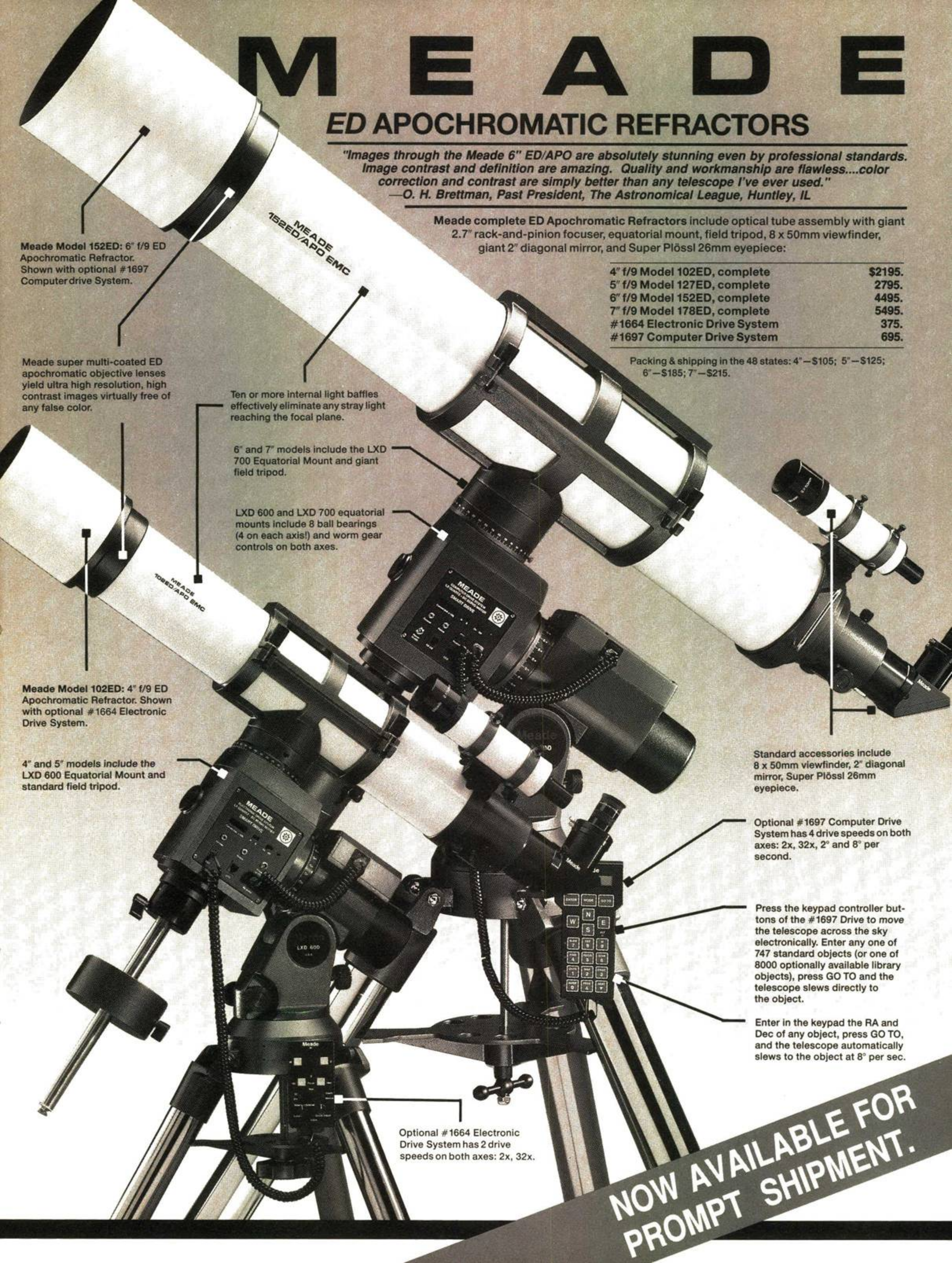
—O. H. Brettman, Past President, The Astronomical League, Huntley, IL

Meade complete ED Apochromatic Refractors include optical tube assembly with giant 2.7" rack-and-pinion focuser, equatorial mount, field tripod, 8 x 50mm viewfinder, giant 2" diagonal mirror, and Super Plössl 26mm eyepiece:

4" f/9 Model 102ED, complete	**$2195.**
5" f/9 Model 127ED, complete	**2795.**
6" f/9 Model 152ED, complete	**4495.**
7" f/9 Model 178ED, complete	**5495.**
#1664 Electronic Drive System	**375.**
#1697 Computer Drive System	**695.**

Packing & shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.



Meade Model 152ED: 6" f/9 ED Apochromatic Refractor. Shown with optional #1697 Computer drive System.

Meade super multi-coated ED apochromatic objective lenses yield ultra high resolution, high contrast images virtually free of any false color.

Ten or more internal light baffles effectively eliminate any stray light reaching the focal plane.

6" and 7" models include the LXD 700 Equatorial Mount and giant field tripod.

LXD 600 and LXD 700 equatorial mounts include 8 ball bearings (4 on each axis!) and worm gear controls on both axes.

Meade Model 102ED: 4" f/9 ED Apochromatic Refractor. Shown with optional #1664 Electronic Drive System.

4" and 5" models include the LXD 600 Equatorial Mount and standard field tripod.

Standard accessories include 8 x 50mm viewfinder, 2" diagonal mirror, Super Plössl 26mm eyepiece.

Optional #1697 Computer Drive System has 4 drive speeds on both axes: 2x, 32x, 2° and 8° per second.

Press the keypad controller buttons of the #1697 Drive to move the telescope across the sky electronically. Enter any one of 747 standard objects (or one of 8000 optionally available library objects), press GO TO and the telescope slews directly to the object.

Enter in the keypad the RA and Dec of any object, press GO TO, and the telescope automatically slews to the object at 8° per sec.

Optional #1664 Electronic Drive System has 2 drive speeds on both axes: 2x, 32x.

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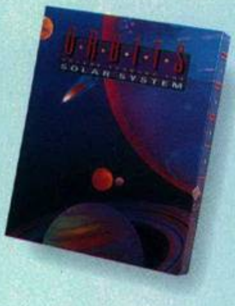

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have a few new instruments that will provide many surprises — for example, the repaired Hubble Space Telescope, the Very Long Baseline Array, and two superb millimeter-wave interferometers at Hat Creek and Owens Valley.

The way astronomers work is changing, too. Instant communication via Internet means that we are all working together more closely. We can move at a collaborative pace that would have astonished our ancestors. This revolution in the way people work, which is only just starting, may turn out to be more significant than any instruments planned for the next two decades. — *Peter B. Boyce, executive officer, American Astronomical Society, Washington, D.C.*

Ancient Mayan astronomers would have noted the twentieth year of Astronomy's publication as a *katun* anniversary and would have erected a carved stone monument, inscribed with anniversary data. No one, so far as I know, has set up a commemorative monument on behalf of Astronomy, but the twenty years of bound copies on my shelves spotlight the value and volume of this publishing achievement.

The ancient Mayan skywatchers would be troubled, I think, by the loss of the Milky Way from our nights and dismayed by a populace that no longer knows the stars and planets. I am too, but I count on Astronomy, which two decades ago designated itself the "world's most beautiful astronomy magazine," to inspire a new generation of eyes to turn skyward and take back the cosmos and the night. — *E. C. Krupp, director, Griffith Observatory, Los Angeles, California*

As I write this I'm on sabbatical leave in Italy on the grounds where Galileo spent the final years of his life. Galileo's telescope was the tool with which his mind sculpted modern science. His fight with the reigning authorities led him to the laws of evidence against which all ideas of science have been tested and accepted over the past four centuries.

Scientists of Galileo's insight, intelligence, and assertiveness are a rarity. We have had our share in the past twenty years. What we need to hope for in the next twenty years are more such intellects. — *Bruce Balick, Osservatorio Arcetri, Firenze, Italy*

As we often tell our students, astronomy is the second oldest profession. As such, it is likely to survive at least another twenty years. If we're lucky, the following *won't* happen in 2013:

- The last red squirrel on Mt. Graham will electrocute itself by gnawing through the power cable left by one of the Columbus project construction workers.
- Chelsea Clinton, Chair of the House Appropriations Committee, will insist on building a new NASA launch facility in Pine Bluff.
- The Multiple Mirror Telescope will be replacing its single primary with 32 small mirrors left over from the Keck IV production run.
- The 27 VLA dishes, continuing the tradition established by the 300-foot Greenbank and 85-foot Hat Creek telescopes, will fall down during the filming of *Star Trek LXXIV*.
- The Space Telescope Science Institute will employ the majority of the 8,000 members of the American Astronomical Society.
- The Space Station will crash into a satellite designed to provide direct broadcast video games for drivers stuck in traffic jams and fall out of orbit onto the Superconducting Supercollider during the dedication ceremonies.
- And, if we ARE so lucky, we will all still be here to read and write for Astronomy with its free, fortieth-anniversary CD containing 100 gigabytes of your favorite astronomical images. — *David J. Helfand, Astronomy Department, Columbia University, New York, New York*

Astronomy has been riding a wave of popularity in recent decades. When I started working as an astronomy writer 15 years ago, my rule of thumb was that most people had no idea what a galaxy was. Now if they say the word, the typical response might be something like, "Galaxy — we live in a galaxy, right?"

In 20 years, if this trend continues, it's possible that most people will feel certain we do live in a galaxy — indeed, that we are riding on a planet in orbit around a star. This collective awareness is important because we need to know Earth as a planet to cherish it properly. And it's important because astronomy is good for people's souls. — *Debbie Byrd, Austin, Texas* □

Astronomy welcomes suggestions and additional information about articles and astronomy in general. Send your letters to Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length and clarity.

NEW HEIGHTS (?) FOR ADVERTISING

by Joseph Baneth Allen

In space no one can hear you scream. Or can they?

Let me explain.

Space Marketing Concepts, Inc., a private company headquartered in Roswell, Georgia, has announced plans to launch a mile-long environmental monitoring platform into space.

"It's very feasible," says Space Marketing CEO Mike Lawson. He hopes to launch the platform in 1996, but a coalition of environmental, scientific, and consumer groups is aiming to prevent the launch of what Space Marketing press releases have called an orbiting billboard that might appear as large as the Full Moon.

"What everyone has been reading and hearing about the 'space billboard concept' is wrong," says Lawson. "It's 99 percent false."

The orbiting platform envisioned by Space Marketing is not a mile-long billboard designed to light up the night sky, he says. "In reality," Lawson explains, " it would be too damn expensive." And it would not have a positive impact on product promotion. For example, if Anheuser-Busch were to launch an orbital billboard promoting Budweiser beer, the company would probably see a negative return for their money because people would be turned off by a giant orbiting beer can wreaking havoc on the night sky, Lawson says.

But product promotion will play a significant role in the orbiting platform Lawson's company is developing. The mile-long, 3/4-mile-wide platform will host an array of ozone depletion monitors and other sensors trained on Earth.

"These ozone and other environmental instruments have been sitting on the shelves and gathering dust at universities for years," Lawson remarks. "We were number one with the technology flow, but we are losing ground to the Japanese, Russians, and Europeans. If we don't do it, eventually they will."

The missing piece of the puzzle for Space Marketing's orbital platform is $30 million. Lawson hopes it will be found in a global company keen on the idea of "eco-branding."

"We want to fly a symbol, like a green dot, on the platform. It would be followed up by a massive public relations campaign on Earth so people would be able to identify the products of the platform's corporate sponsor."

The potential negative astronomical impact of the orbital platform would be negligible, claims Lawson. Given that the platform is traveling at 18,000 miles per hour and that 140 nautical miles' altitude is the low point in its orbit, a concerned observer would have to know exactly where overhead to look to see it. And it would be visible only during daylight hours. No astronomer would have the night sky obstructed by the Space Marketing Concepts orbital platform, claims Lawson.

Others, however, are not so convinced the platform is merely a vehicle for scientific research with a small eco-brand on the side.

"Space Marketing's own press releases quote Lawson as seeking an 'environmental billboard' that can be seen from space," says Karen Brown, research director for the Center for the Study of Commercialism, based in Washington, D.C., Brown is in the final stages of forming a coalition of scientific, environmental, and consumer groups to oppose the launch of Space Marketing's orbiting platform/billboard.

"We have asked Space Marketing for any information on the project that would make a protest unnecessary," says Brown. Technical descriptions furnished by Space Marketing clearly show the platform as an orbiting billboard, however. Moreover, part of the sales pitch made to would-be clients is that the orbiting billboard could "reach a potential audience three-to-five times greater than the television audience for the Super Bowl." As Brown explains, "We're leery of the change in tune."

The concerns of Brown and her coalition center on a Space Marketing press release dated April 12, 1993, in which Lawson is quoted as saying, "A tremendous opportunity [exists] for a global-oriented company to have their logo and message seen by billions of people on a history making, high profile vehicle. Imagine attending the [1996 summer Olympics] in Atlanta and in the sky floats the logo and

[continued on page 15]

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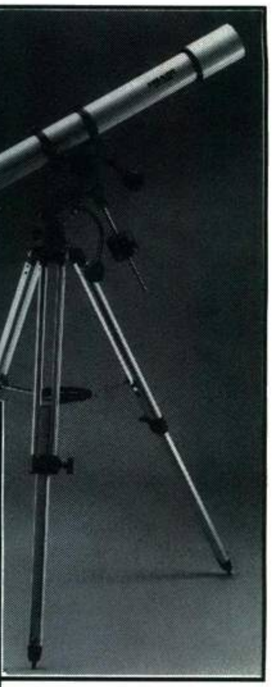

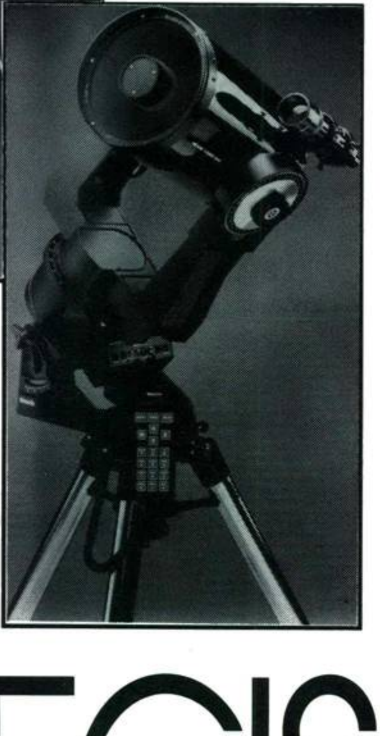

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message of your favorite soft drink, not on a blimp, not towed by an airplane, but actually orbiting in space, miles above Earth, and visible throughout the world with the naked eye."

"There will be some type of advertising on the platform," admits Ronald Humble, assistant professor of engineering at the University of Colorado and chief engineer for Space Marketing's orbiting platform/billboard. To get corporate America to foot the $30 million bill for the inflatable platform and its ozone-mapping mission you have to give them some type of advertising, he says.

"The platform will be visible just during the day," Humble notes, "with the best viewing at sunrise and sunset. It will have a low-Earth, Sun-synchronous orbit, with the exact inclination determined by the corporate sponsor." Plans call for the platform to be launched by an Atlas or a Delta rocket. Humble also adds that the platform will be a test of inflatable spacecraft for a manned Mars mission proposed by engineers at the Lawrence Livermore National Laboratory.

"In Space Marketing's descriptions, the original plan was to use it at night," says physicist Robert Park, spokesman for the American Physical Society, the nation's leading organization of physicists. "The plan also called for the billboard to be illuminated by mirrors. Obviously, they've been a little stunned by public reaction against their space billboard."

Park has called the orbiting billboard horrifying and absurd. "It's pollution to the Nth degree. And once the fuel runs out and the orbit decays, you can't control where it will be seen in daytime or nighttime. You can't escape it."

Atlanta mayor Maynard Jackson agrees with him. Jackson shot down his city marketing director's suggestion to sell advertising on Space Marketing's orbital billboard when the city hosts the 1996 Olympics. "It's environmental pollution. I don't want to see a billboard marring the sky," Jackson told the Atlanta Constitution newspaper.

Despite all the hoopla generated by Space Marketing's plans to launch its combined billboard/ozone platform, one simple fact has been overshadowed. Minus a corporate sponsor willing to shell out $30 million, Space Marketing's concept will likely remain grounded long past the '96 Olympics.

Let's hope. □

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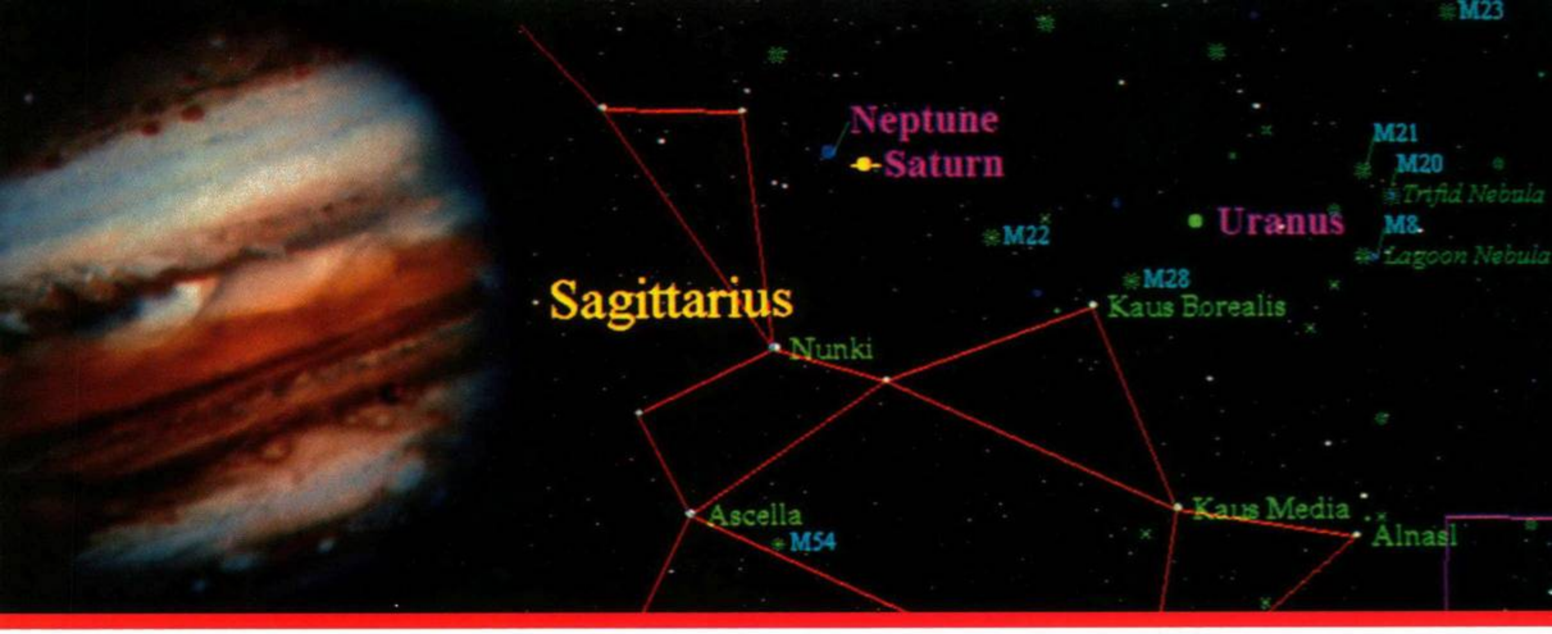
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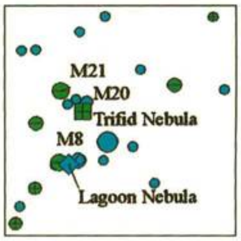

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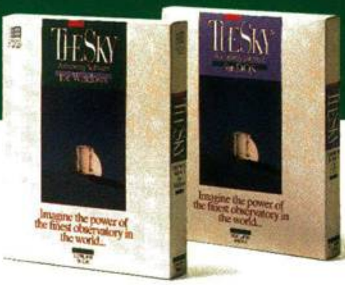
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WHEN WORLDS COLLIDE: COMET WILL HIT JUPITER

One of the strangest comets ever discovered will end its existence in an equally strange fashion — by colliding with Jupiter. The result could be the most unusual astronomical sight ever witnessed from Earth.

According to recent predictions, Comet 1993e, better known as Periodic Comet Shoemaker-Levy 9, will hit Jupiter sometime on July 22, 1994. The comet passed within 31,000 miles of Jupiter's cloudtops on July 8, 1992, a close encounter with Jupiter's immense gravitational pull that evidently broke the comet into several fragments. When the comet was discovered on March 24, 1993, by Eugene and Carolyn Shoemaker and David H. Levy, 1993e appeared to have 17 icy nuclei strung out along a line. The comet now appears to be orbiting Jupiter although astronomers do not know when it entered Jovian orbit.

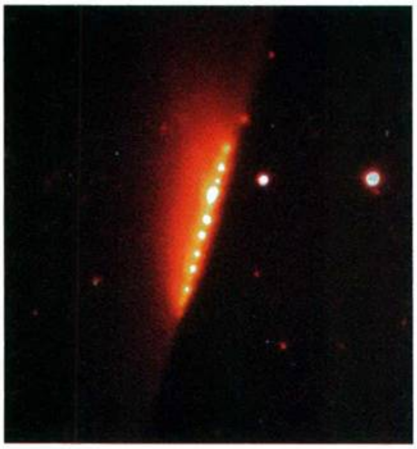
Next July the comet fragments will collide with Jupiter over a period of one day. In late May, Donald Yeomans of the Jet Propulsion Laboratory estimated the odds of collision to be 64 percent. At the time of impact, the 17 comet nuclei will be spread along a line at least 20 arcminutes long, about two-thirds the apparent diameter of the Full Moon and about 30 times the diameter of Jupiter.

If the train of nuclei strikes Jupiter with a glancing blow, any surviving nuclei could remain in orbit as satellites of Jupiter, perhaps breaking apart to form a Saturn-like ring of debris, or be thrown closer to the Sun.

The fragments that do hit — and it seems most likely that all will hit — will collide with a force that JPL's Zdenek Sekanina calls "a truly horrendous amount of energy." Sekanina estimates the total amount of energy released into the atmosphere of Jupiter will equal the explosion of several million megatons of TNT, a force hundreds of thousands of times greater than the force unleashed by the Tunguska comet explosion over Siberia in 1908.

Clark Chapman of the Planetary Science Institute ups the ante even further. Writing in the June 10, 1993 issue of *Nature*, Chapman estimates the impact energy will equal a billion megatons. The only other event in history of comparable force is the asteroid or comet that may have struck Earth 65 million years ago, which some scientists speculate wiped out the dinosaurs. As Chapman explains, "This once-in-a-hundred-million-year event dramatically affected the evolution of life on our planet. Who would have thought that we might ourselves witness a cosmic impact of comparable proportions?"

Although the size of the comet fragments is still uncertain, estimates put the largest at about 10 kilometers across. When the comet nuclei strike the Jovian atmosphere, they will be traveling at over 200,000 km per hour relative to Jupiter. The largest parts of the comet will no doubt fragment into smaller pieces. Sekanina calculates that the largest pieces will penetrate the atmosphere to a depth of several tens of kilometers, bringing them down to a layer some 40 km above the point where the Jovian atmospheric pressure equals one Earth atmosphere, or one bar.


Jane Luu, University of California, Berkeley

LIKE A STRING OF BOMBS, the long train of icy nuclei from Comet Shoemaker-Levy 9 will collide with Jupiter in 1994, producing a rare display.

At that point the fragments will explode in a flash. What visible effect the collisions will have is still a guess. All the fragments are expected to strike near Jupiter's South Tropical Belt. The fragments will hit Jupiter on the dark side of the planet, putting the collision points out of sight from Earth. However, the rapid rotation of Jupiter will soon bring these points into view.

According to New Mexico State University's Reta Beebe, "If the comet nuclei excavate down to the 700 millibar level, the explosions should cause ammonia ice to well up to the top layers of Jupiter's atmosphere. The ice crystals will form high cirrus clouds that will create an abnormally bright equatorial cloud zone."

John Lewis of the Lunar and Planetary Laboratory estimates that if the impacts occur on Jupiter's front side, the explosions would be visible from Earth through a telescope even during the day. If the comet pieces hit Jupiter's far side (its night hemisphere) light from the explosions may brighten Jupiter's moons.

Needless to say, amateur and professional astronomers will be watching Jupiter closely next July for an event that will rank as one of the rarest in astronomy.

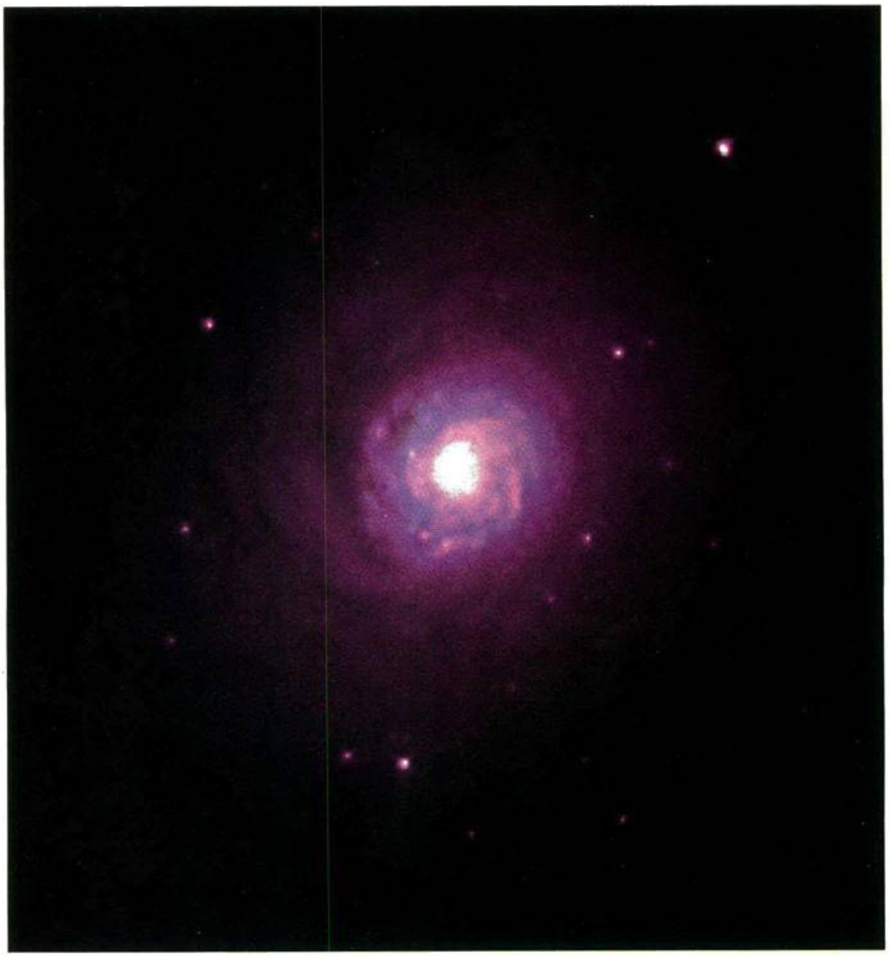
More detailed predictions of what will happen in 1994 will be possible only after astronomers have collected observations of this unusual comet taken over the summer of this year. Through August and September, Shoemaker-Levy 9 is expected to remain at magnitude 14, a very faint target for amateur telescopes. On August 1, its right ascension (using epoch 2000 coordinates) will be 12h25.9m and its declination –3°54.2'. On August 11, its RA will be 12h32m and its declination –4°31.9'.

CAN A SPIRAL BECOME AN ELLIPTICAL?

Roughly a billion years ago, two galaxies in the constellation Aquarius rammed into each other. Now astronomers using the Hubble Space Telescope have peered into the turbulent core of the resulting galaxy, a peculiar galaxy known as NGC 7252. There they discovered a collection of exceptionally young and bright globular star clusters and a pinwheel-shaped disk of stars and gas rotating in the opposite direction from the rest of the galaxy. The findings support the notion that giant elliptical galaxies can form when spiral, or disk-shaped, galaxies collide.

The research team, led by Bradley Whitmore of the Space Telescope Science Institute and Francois Schweizer of the Carnegie Institution of Washington, located 40 clusters in the inner re-

A "MINI SPIRAL" of stars and gas as well as some 40 bright, young globular clusters lie in the heart of the peculiar galaxy NGC 7252, seen in this Hubble image. Both features apparently formed when two disk-shaped galaxies collided about a billion years ago



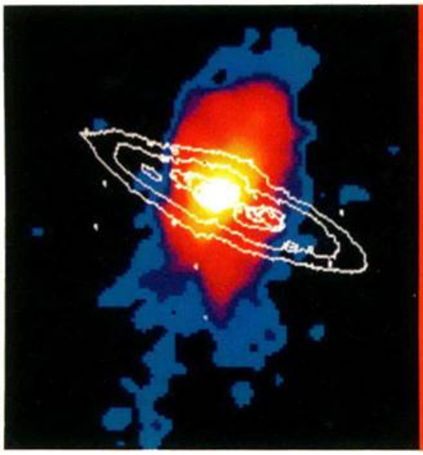
Bradley Whitmore (STScI) and NASA

gion of NGC 7252. Hubble's sharp eye was also able to resolve the clusters, which typically measure 0.04 arcsecond in diameter. At the galaxy's distance of 300 million light-years, this corresponds to about 60 light-years, the same size as globular clusters in the Milky Way Galaxy.

But the proof that these clusters are globulars came from spectrograms of the two brightest ones taken with the 200-inch Hale telescope at Palomar Observatory. These are not ordinary globulars — they are up to a few hundred times brighter than globulars in our Galaxy because they contain many hot, luminous blue stars. Because such stars are short-lived, their presence implies that the clusters are very young, probably only 50 million to 500 million years old, compared with the 15-billion-year age of Milky Way globulars.

Many astronomers think that giant elliptical galaxies form when disk-shaped galaxies collide. One problem with this hypothesis has been that giant ellipticals tend to have more globular clusters than would be expected by adding together the globulars of colliding disk-shaped galaxies. But the new Hubble observations resolve this dilemma by showing that the collision itself can create new globulars.

The "mini-spiral" seen at the center of NGC 7252 resembles a full spiral galaxy seen face-on. But the disk is only about 10,000 light-years across, just 1/20 the diameter of the entire galaxy, and contains enough gas to make about eight billion stars like the Sun. The striking pattern presumably formed after the original galaxies collided, which triggered an infall of gas into the core and the subsequent birth of new stars. The minispiral's rotation in the direction opposite to its host galaxy provides another piece of evidence that NGC 7252 formed when two spiral galaxies collided.



Joel Bregman and Eric Schulman

SUPERNOVA EXPLOSIONS HEAT THE GAS in the irregular galaxy M82 in Ursa Major. The hot gas glows brightly in X rays, which were captured in false color by the ROSAT satellite (white shows the strongest emission and blue-black the weakest). The white contours represent M82's visible light. The X rays come from gas heated to over 10 million kelvins by a succession of ancient supernovae in the inner part of the galaxy. The hot gas has escaped the galaxy's disk and is now rushing away in two oppositely directed flows that extend more than 20,000 light-years.

DARK MATTER ISN'T EVERYWHERE

If you read ASTRONOMY regularly, you may well think that dark matter is everywhere. Astronomers have found huge amounts of dark matter — matter that gives off little if any light but does exert a gravitational pull — in spiral galaxies, dwarf galaxies, galaxy clusters, and some elliptical galaxies. In fact, astronomers think that dark matter makes up 90 percent or more of the mass of the universe. But a study of the motions of stars in M105, a normal elliptical galaxy in the constellation Leo, shows that it contains no dark matter. Robin Ciardullo of Pennsylvania State University and George Jacoby of Kitt Peak National Observatory announced their findings at the June 1993 American Astronomical Society meeting in Berkeley, California.

Stars in every galaxy move under the influence of gravity, and the faster they move, the more gravity is needed to prevent them from leaving the galaxy. Because gravity is proportional to mass, astronomers can "weigh" a galaxy simply by measuring the velocities of its stars.

But it is exceedingly difficult to measure the velocities of stars in an elliptical galaxy. Ciardullo and Jacoby instead weighed M105 by measuring the speeds of that galaxy's planetary nebulae, which are brighter than most stars and emit most of their light at a small number of specific wavelengths, so they stand out clearly when viewed through certain filters.

The researchers found that the planetary nebulae in M105 move as if there were no dark matter. Near the center of the galaxy, where lots of visible mass resides and gravity is strong, the nebulae move fast; on the outside, where the galaxy's visible matter provides only a weak gravitational attraction, the nebulae move slowly. Says Ciardullo, "The overall behavior is exactly what you would expect from a galaxy made of normal stars." Apparently no dark matter is present. Is M105 typical of elliptical galaxies? Although it's far too early to answer that question, these new observations should warn astronomers not to take the distribution of dark matter in all galaxies for granted.

Pennsylvania State University and NOAO

WHAT YOU SEE IS WHAT YOU GET in M105, a 9th-magnitude elliptical galaxy in Leo. New observations show that the only matter in M105 is the normal, visible kind — unlike most other galaxies, it contains no dark matter.

WATER FOUND ON JUPITER'S MOON IO

Jupiter's moon Io has long been known to have a surface coated with sulfur compounds. Now a team of scientists led by Farid Salama of NASA's Ames Research Center have found evidence for water on this volcanically active moon. The water molecules appear to be frozen and mixed with frozen sulfur dioxide around some of Io's volcanic vents. "Our favored picture is that the water results from volcanic activity on Io. When the mixture of hot

Space News

MARS OBSERVER WILL POWER INTO ORBIT

Mars Observer is all set. On August 24 the space probe will fire its engines and enter a looping orbit around Mars. Launched in September 1992, the NASA spacecraft will spend two years mapping the surface of Mars and monitoring its weather. (See "Return to the Red Planet," September 1992.)

The original flight plan called for Mars Observer to spend three months after arriving gradually lowering its orbit around Mars from its initial long, elliptical orbit to a low, circular one better suited to scanning Mars. Science observations were originally set to begin December 12.

However, thanks to very accurate aiming after Mars Observer's launch from Earth, flight controllers have had to use far less fuel for flight path fixes on the way to Mars. When Mars Observer arrives at its destination, controllers will use the extra fuel to perform a "power in" approach, braking the spacecraft and dropping it more rapidly to its low-altitude mapping orbit. If all goes according to plan, Mars Observer will begin mapping November 22. The early date should allow the spacecraft to get in one 26-day-long mapping cycle of the entire globe of Mars before the planet disappears behind the Sun on December 20 and ground controllers lose communication with the spacecraft for two weeks.

VOYAGERS DETECT EDGE OF SOLAR SYSTEM

The two Voyager spacecraft have detected low-frequency radio emissions that may be from the edge of the solar system. The radio emissions come from a region called the heliopause, the boundary between the solar wind and the interstellar medium. The heliopause is about 80 to 100 astronomical units away from the Sun (1 AU equals the distance from Earth to the Sun). It marks the point where the Sun's influence ends and interstellar space begins. Both Voyagers, although now past the orbit of Pluto, are still a long way from the heliopause. Voyager 1 is currently 51 AUs from the Sun while Voyager 2 is 40 AUs away. While detecting the heliopause is one of the goals of the ongoing Voyager Interstellar Mission, the Voyagers will not actually cross the heliopause until 2010.

MAGELLAN BEGINS AEROBRAKING

On May 25, the Venus-orbiting Magellan probe ended its primary Venus mapping mission and began a planned series of dangerous dips through the Venusian atmosphere. Called aerobraking, these maneuvers are designed to circularize Magellan's orbit.

Since late 1990 Magellan has been orbiting Venus in a highly elliptical orbit suited for its prime radar-mapping mission. Magellan conducted three 243-day-long mapping cycles around the cloud-covered planet, successfully charting 98 percent of the Venusian surface. The radar mapping was followed by an 8-month-long fourth cycle devoted to charting the gravitational field of Venus. The gravity mapping allows astronomers to "see" the structures underlying Venus' surface features.

However, from its 105-mile by 5,300-mile elliptical orbit Magellan could map the gravity of only Venus' equatorial regions with any detail. To map the poles requires a low-altitude circular orbit. After three months of aerobraking maneuvers Magellan should be left orbiting Venus at an altitude of 125 to 375 miles. If the money can be found to finance the extended mission, then starting this autumn, Magellan will conduct a fifth cycle of high-resolution gravity mapping.

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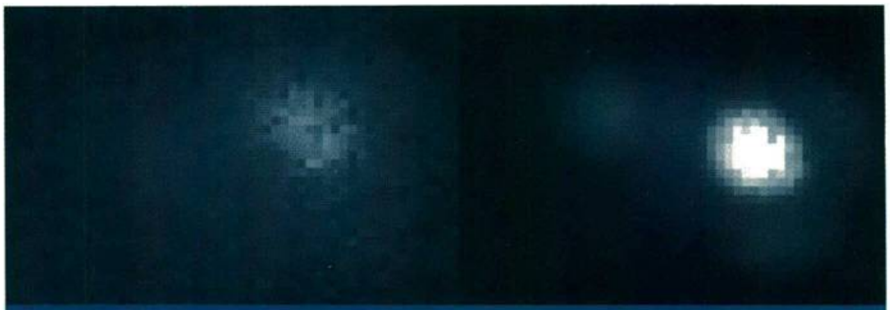
water vapor and sulfur dioxide gases expands out of the vent, it condenses into ices that fall back onto Io's cold surface," says Ames' Louis Allamandola. Astronomers discovered the telltale traces of water by examining the infrared spectrum of Io obtained using the Kuiper Airborne Observatory. This high-flying jet has a 36-inch telescope that observes in the infrared while flying above 99 percent of Earth's own water vapor.

PULSAR SIGHTED BEYOND MILKY WAY

Astronomers from Ireland, Denmark, and the European Southern Observatory have made the first optical identification of a pulsar beyond the Milky Way Galaxy. The astronomers found the pulsar in the Large Magellanic Cloud using the 3.5-meter New Technology Telescope at La Silla in Chile. The new object is only the third radio pulsar, after the Crab and Vela pulsars, to be definitely linked to an optical image. The pulsar's similarity to the well-studied Crab Nebula pulsar has earned it the nickname the "Crab Twin."

The extragalactic pulsar was first detected in 1984 when the Einstein satellite discovered X-ray pulses coming from the Large Magellanic Cloud. The pulsar was later found to also emit radio waves, which appear to be coming from a neutron star spinning around its axis every 0.05 second.

To detect pulses of visible light from the spinning neutron star, astronomers used an ultra-sensitive camera to detect individual photons of light as they arrived at the telescope. The camera recorded the exact position and arrival time of each photon. With a visual magnitude of only 22.5, the neutron star is very faint. In fact, the telescope detected only two photons per second. The neutron star's rapid rotation suggests this could be the third youngest pulsar known. — *Peter Bond*



Steward Observatory

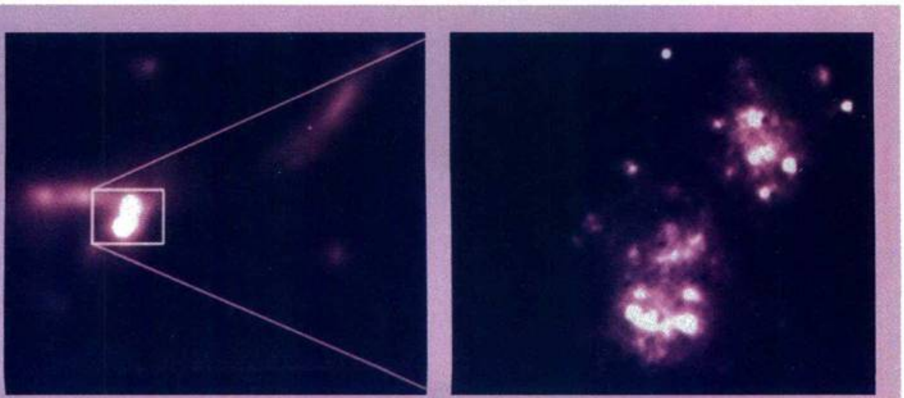
VIEWING T TAURI'S COMPANION is now possible with adaptive optics, which correct a telescope's image for the blurring effects of Earth's atmosphere. The picture at left shows the uncorrected view, while the image at right shows the improved image taken with the adaptive optics system on the Multiple Mirror Telescope, south of Tucson, Arizona. Michael Lloyd-Hart and his colleagues at the University of Arizona's Steward Observatory used the infrared images to show that the companion to T Tauri is undergoing an energetic outburst, the second in two years. The outburst results from changes in the circumstellar disk of this young star.

BRIGHT DOUBLE QUASAR DISCOVERED

Astronomers at the European Southern Observatory have discovered the brightest known double quasar. The unexpected discovery came during a survey of quasars being conducted by Lutz Wisotski and Thorsten Kohler of the Hamburg Observatory in Germany. A chance alignment of the slit in the spectrograph allowed the astronomers to pick up the light from a hitherto unknown object next to a bright quasar. The companion has a spectrum almost identical to that of the original quasar. The brighter component has a magnitude of 16.2 while the dimmer component has a magnitude of 18.0, making this the brightest known double quasar system.

Their close separation of three arcseconds and identical redshifts initially suggested the twin quasars were an example of a gravitational lens. In such a lens, the gravity of a massive object between us and the quasar splits the light from a single quasar into multiple images.

But new observations made in May show that the spectra of the two quasars are slightly different and that they may in fact represent two separate objects. However, if the pair does turn out to be a gravitational lens, time delays between fluctuations in the brightness of the twin components could help determine the distance scale of the universe. — *Peter Bond*



Todd Small, Caltech

Peter Conti, University of Colorado/NASA and ESA

MERGING GALAXIES CREATE BURSTS of star formation as seen in this Hubble image (far right) of NGC 1741, a member of the class called peculiar galaxies. Ground-based views of the galaxy (right), which lies in the constellation Eridanus, exhibit only a double-lobed shape. Hubble shows that these lobes are star-forming regions separated by 3,000 light-years. Each knot is 150 light-years to 300 light-years in diameter and may contain up to a thousand stars. Observations made after the Hubble servicing mission should determine whether these knots formed sequentially or at the same time.

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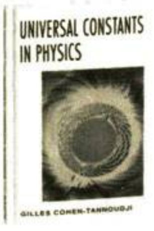
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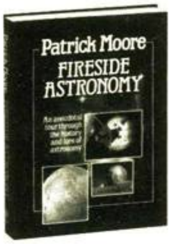
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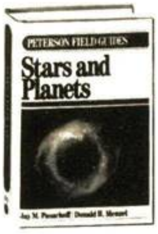
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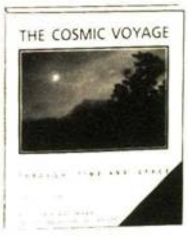
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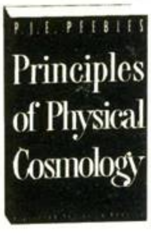
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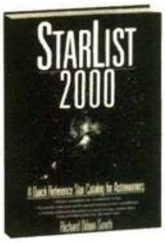
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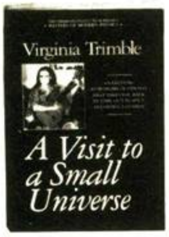
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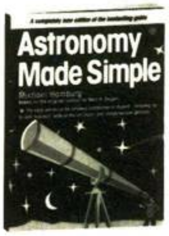
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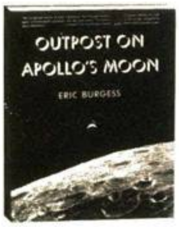
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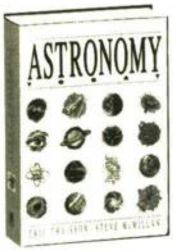

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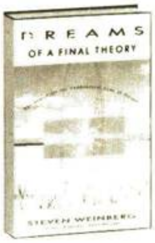
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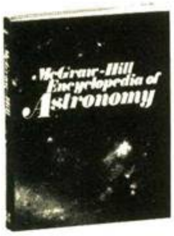
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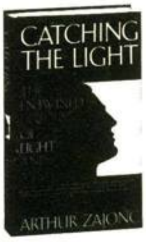
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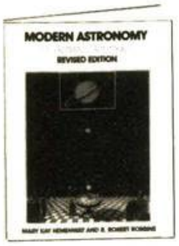
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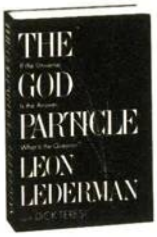
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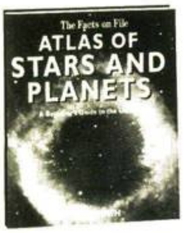
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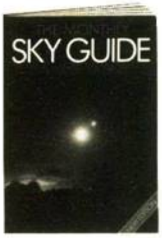

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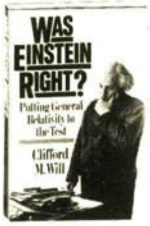
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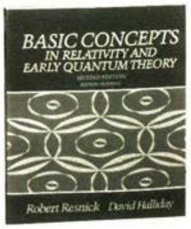
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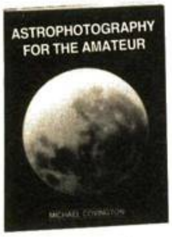
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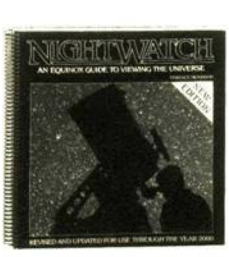
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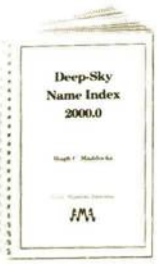
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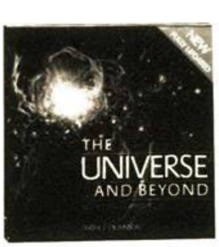
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Astronomy 9/93

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Amateur News

BRITISH DEEP-SKY OBSERVERS MEET

About 150 of England's most active amateur astronomers met on June 5, 1993, to share their views on deep-sky observing and imaging. The annual meeting of the Webb Society, England's national group of deep-sky astronomers, attracted amateurs from across Europe and even the United States. The Webb Society, founded in 1967, was named for the accomplished 19th-century observer Thomas William Webb, author of *Celestial Objects for Common Telescopes*.

The event took place at the Royal Greenwich Observatory in Cambridge, England. Steeped in history, the city's many attractions include Trinity College, where Isaac Newton revolutionized physics and mathematics.

Early in the morning, telescopes began to fill the hallways of the RGO, and sales tables contained a wide selection of astronomical books and devices such as CCD cameras and computer software. Throughout the morning and at 3:30 p.m. tea time, attendees milled about and swapped stories of their latest observations, telescope projects, and equipment needs.

Shortly before noon, Webb Society president Bob Argyle, an astronomer at the RGO specializing in double star research, called the meeting to order. The day's five talks covered a wide range of topics within deep-sky astronomy. Observer Terry Platt described a CCD camera he has constructed and plans to offer commercially. Peter Meikle described his observations at the RGO of supernova 1993J in the galaxy M81, meticulously describing the object's light curve. John Smith covered Schmidt cameras and their uses for wide-field deep-sky photography. Alan Dowdell described how to sketch galaxies and nebulae and displayed examples of many people's work.

The annual address titled, "Deep Sky Observing — One American's View," was presented by Dave Eicher, associate editor of ASTRONOMY. Eicher described the mini-revolutions occurring in visual observing (people spotting faint, challenging objects), conventional photography (high-grade, deep exposures on black-and-white film), and CCD imaging. Afterward, members engaged in a lively discussion about the differences between British and American backyard astronomy, which reflect the different cultural attitudes. British amateurs bring a more serious approach to observing in that they want to produce scientific results. Americans observe primarily for recreation alone.

ASTRONOMY: David J. Eicher

THE ROYAL GREENWICH OBSERVATORY in Cambridge, England, hosted the annual meeting of the Webb Society in June.

The Webb Society's publications include the *Quarterly Journal*, containing observational reports, *The Deep-Sky Observer*, a magazine containing correspondence and articles, and occasional monographs. For information on membership in the Webb Society, write Ronald J. Morales, Webb Society North America, 1440 South Marmora, Tucson, AZ 85713.

"ASTROIMAGE SEMINARS" SCHEDULED

Since 1976 astrophotographers from around the country have converged on southern California every two years for the Astrophoto Seminar. Begun in 1976 by Charles Townsend, Byron Groves, and John Sanford, the biennial seminars have been organized by the Ventura County Astronomical Society and the Orange County Astronomers. Each seminar features talks by astrophotography experts, a photography exhibit, and displays by companies offering products in the field.

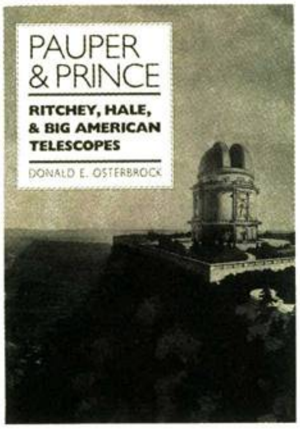
In alternate years, the clubs have staged the Electronics Oriented Seminar geared to users of CCD cameras and other electronic detectors. However, at this year's Astrophoto Seminar, the tenth such event, organizers announced that the two biennial events will be merged into one annual "Astroimage Seminar." The first will be held March 5, 1994.

At the 1993 Astrophoto Seminar more than 150 people attended the day-long program of talks and product displays. Held March 6 at Fullerton State University, the program contained lots of information about using CCD cameras.

Ron Arbour of Hampshire, England, showed results from his 500x256-pixel "Starlight Express" CCD which he has developed and is now distributing in North America. Alan Holmes of Santa Barbara Instrument Group showed several approaches to tricolor deep-sky astrophotography, particularly with his company's ST-6 CCD camera. In a video-taped presentation, Richard Berry demonstrated his tricolor image-processing programs. Brad Wallis related the problems he encountered in calibrating and filtering CCD cameras to make tricolor astroimages. Charlie Oostdyk of the Orange Country Astronomers gave a well-received presentation: rotation movies of Mars and Jupiter made from CCD images taken at the Pic du Midi Observatory in France.

CCDs shared the stage with conventional photography. Klaus Brasch of San Bernardino showed his method of enhancing planetary photographs, which was the subject of an article in the February 1993 ASTRONOMY. Chris Schur showed that traditional astrophotography is not dead with his superb 2415 Technical Pan images of nebulae along the Milky Way. Rick Hull of the Orange County Astronomers related his success in the search for higher contrast in color deep-sky photography. Graham Flint of San Diego discussed his project of photographing the Milky Way with large-format aerial cameras. Finally, Alan McFarlane of Seattle told of his "Solar Eclipse Trip from Hell" when he went to Hawaii in July 1991 to tape the event for NBC News and ran into virtually every problem he could have, including clouds that blotted out most of the eclipse.

A 40-page Proceedings book is available by mail from OCA Publications at 2195 Raleigh Avenue, Costa Mesa, CA 92627, for $14.00 prepaid in U.S., $15.00 by air foreign. You can also order an edited VHS video of the event for $24.95 from the same address. — *John Sanford*



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Donald Osterbrock now tells Ritchey's story, tracing his career and revealing its complex interrelationship with Hale's. He also covers the telescope-building aspects of Hale's life at Yerkes, Mount Wilson, and Palomar observatories, and shows how these men helped the United States take the lead in developing major astronomical facilities.

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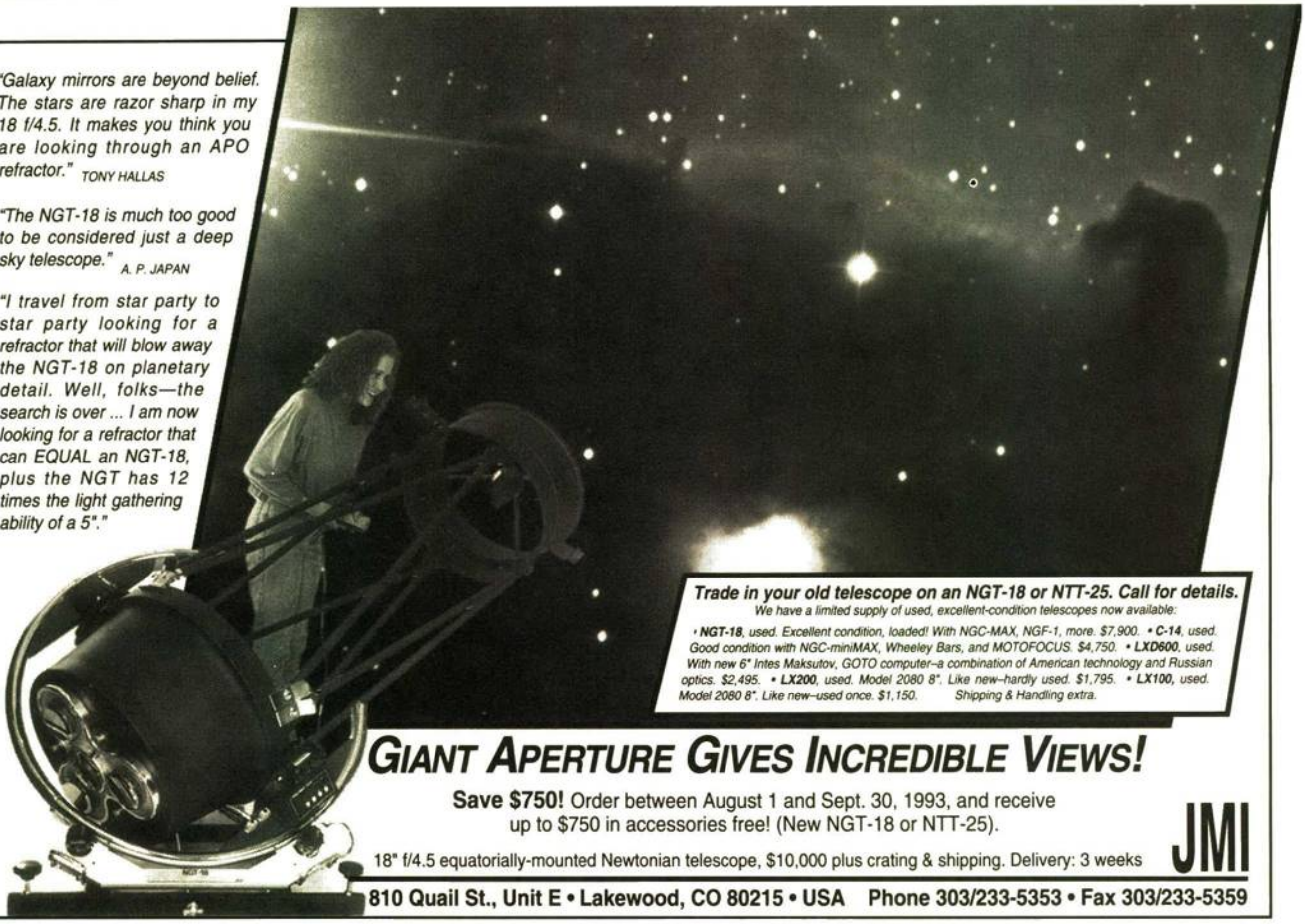

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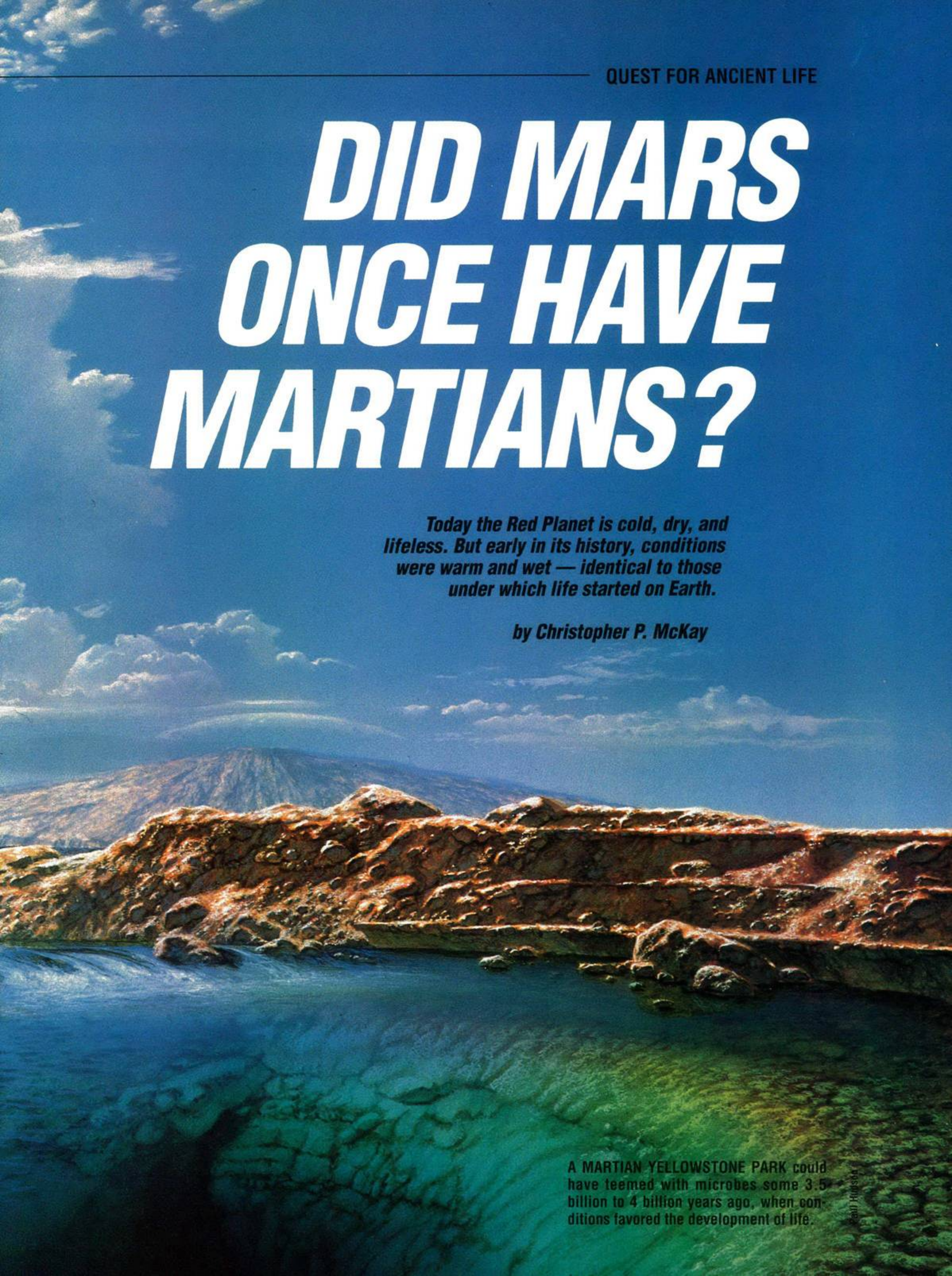
QUEST FOR ANCIENT LIFE

DID MARS ONCE HAVE MARTIANS?

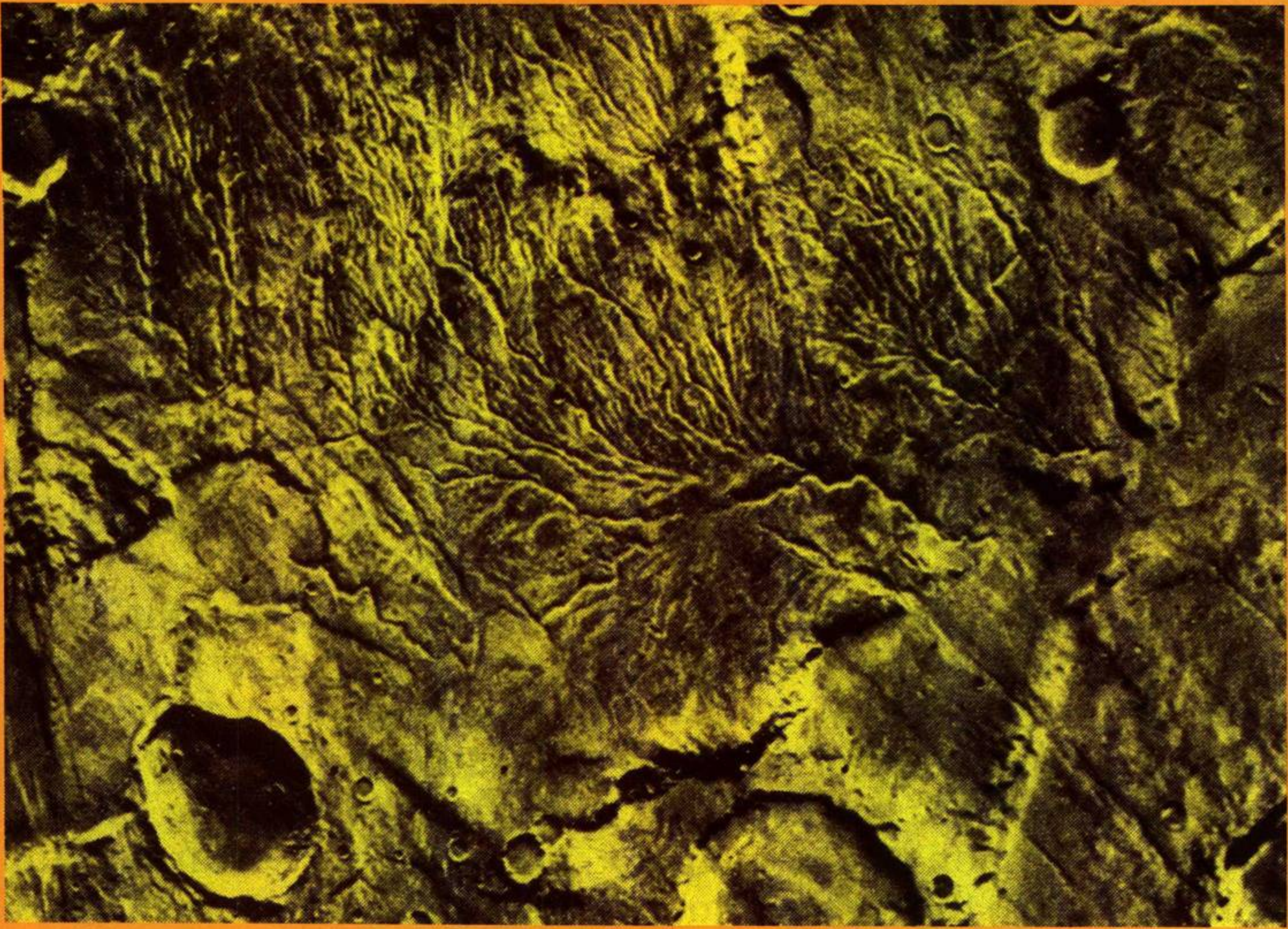
Today the Red Planet is cold, dry, and lifeless. But early in its history, conditions were warm and wet — identical to those under which life started on Earth.

by Christopher P. McKay



A MARTIAN YELLOWSTONE PARK could have teemed with microbes some 3.5 billion to 4 billion years ago, when conditions favored the development of life.

Paul Hudson



NASA

MARTIAN VALLEY NETWORKS in the ancient cratered terrain of the southern hemisphere offer the best evidence that liquid water flowed on Mars some 3.8 billion years ago. Thus the planet must have been warmer and had a much thicker atmosphere than today.

A new phase in the exploration of the Red Planet begins on August 24, when the Mars Observer spacecraft arrives there. Our return gives Mars scientists a new shot at an old question, one that has forever intrigued them: Is there life on Mars? Or, just as intriguing, was there *ever* life there? Results from recent studies point more and more toward an early Mars that was astonishingly like the early Earth when life gained a foothold here.

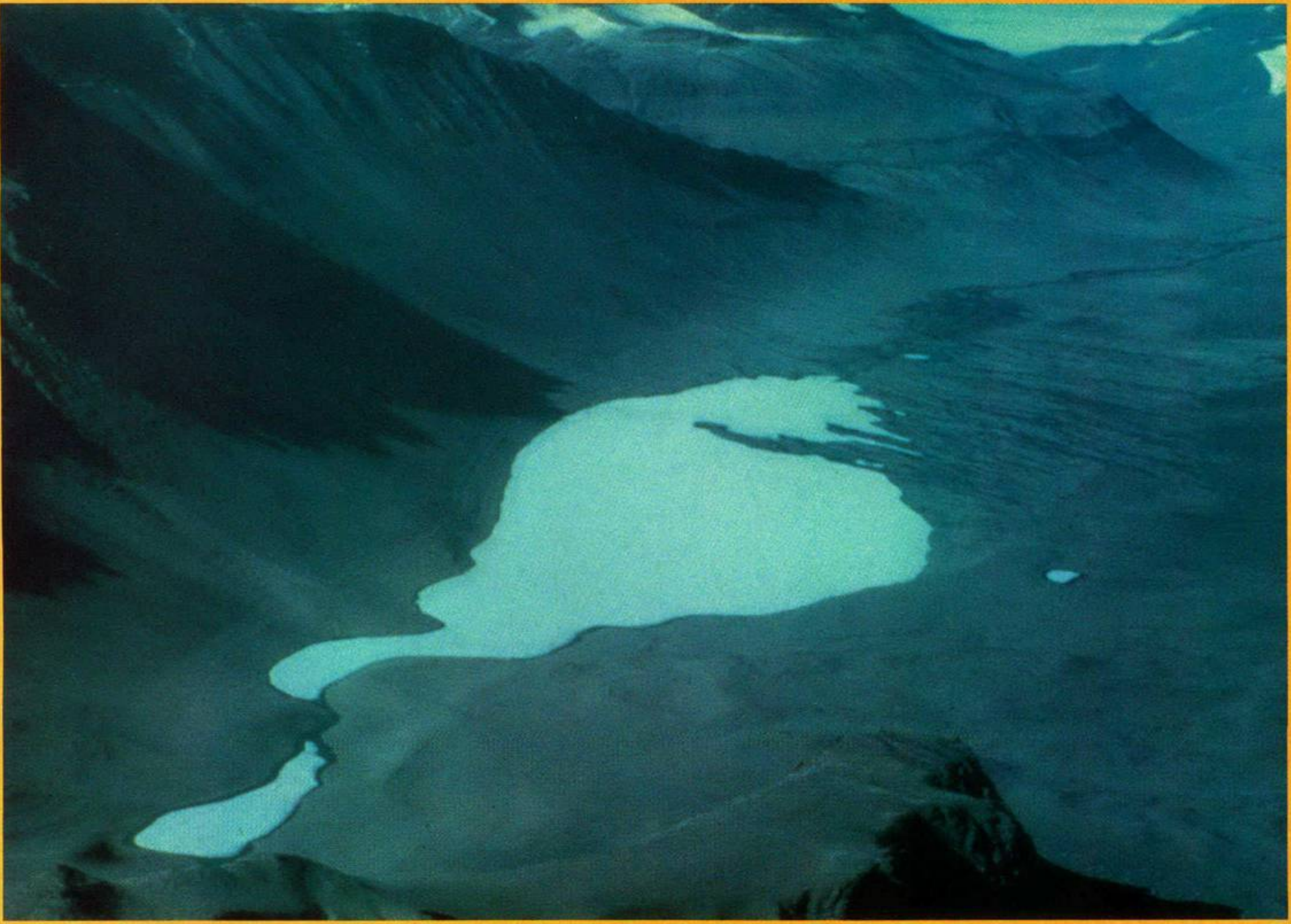
The last successful mission to Mars, the Viking project in 1976, focused in vain on the search for life. Its two landers touched down at distant but similar sites on the northern plains of Mars. They analyzed the composition of the Martian soil and atmosphere, conducted meteorological observations for three Mars years, and most importantly analyzed the Martian soil for evidence of microbial life.

Each Viking lander carried a biology package consisting of three experiments that incubated the Martian soil and looked for signs of metabolic activity. Each lander also possessed a mass spectrometer for identifying organic molecules in the soil. The soil incubated in the Viking biology experiments showed activity which in some ways mimicked what scientists expected from life but which was unlike activity seen in any soils tested on Earth before the mission. The mass spectrometer did not, however, detect any organic molecules in the soil, even at a level of just a few parts per billion. Because life on Earth literally teems with organics and sheds the stuff everywhere in its environment, it is hard to imagine that life could exist on Mars today with no trace of organics in the soil.

This evidence against life is compounded by a general problem: the absence of liquid water. Temperatures on Mars are so cold and the atmospheric pressure so low that water cannot exist as a liquid on the Martian surface, and liquid water is an essential feature of life on Earth. Thus the lack of organics and the absence of liquid water all but rule out the possibility that life now exists on the surface of Mars.

Looking for Past Life

Conditions on Mars were not always so hostile, however. The most exciting results from Viking on the question of life came not from the biology experiments on the landers but from the cameras on the orbiters. The images returned from Viking and from the Mariner 9 spacecraft that arrived several years earlier showed features that seemed to be clear evidence of copious liquid water at some time in Mars' past.



R. Vestal

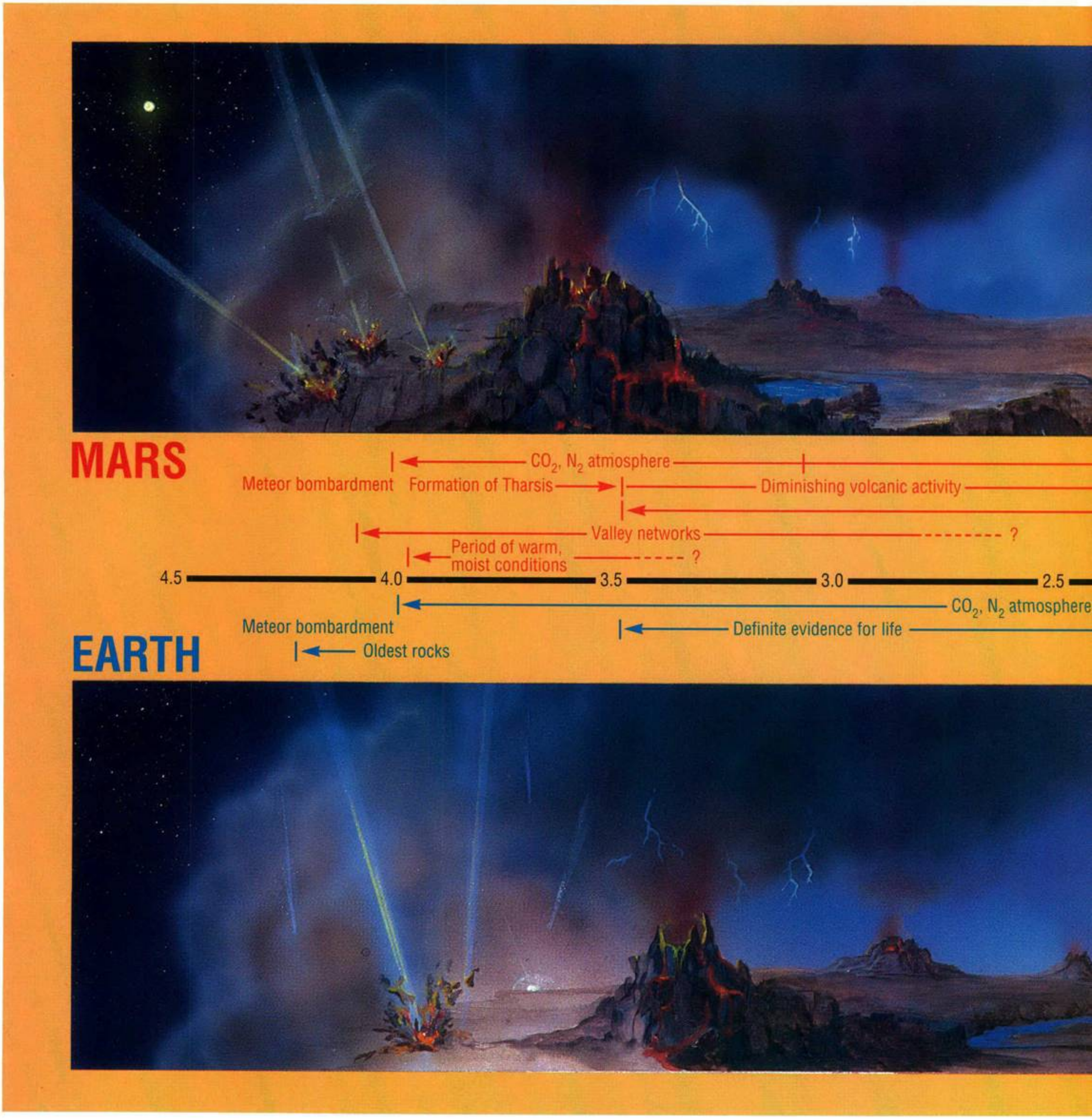
A BIT OF MARS ON EARTH exists in Wright Valley in Antarctica. Frigid temperatures and almost no precipitation make the valley and Lake Vanda reminiscent of Martian conditions, yet they play host to thriving colonies of algae and lichen.

Two kinds of features seen in the images of the Martian surface point unambiguously to the action of flowing water. One is the outflow channels, large features that appear to be the result of catastrophic outflows of liquid water from water-bearing rock formations, or aquifers, beneath the Martian surface. Planetary astronomers think the outflows were triggered by the melting of ice that was holding back the liquid water. Some of these outflow channels appear to be quite young geologically speaking — less than a billion years old, which makes them particularly intriguing from the point of view of a search for life: Their young age suggests that subsurface, liquid-water reservoirs may still exist on Mars.

The other water-carved features are the valley networks, sinuous valleys that in many cases form highly branched and meandering drainage patterns. Some clearly seem to suggest rain or snow as the source of the liquid water. But rain and snow don't exist in the present Martian climate. Temperatures and atmospheric pressures are too low for any significant precipitation, even snow. Furthermore, if water were to start flowing in the slow, easy way indicated by the networks, it would freeze solid. This distinguishes the networks from the outflow channels, in which the water flowed with such vigor that it would not freeze even under current conditions.

So it's clear that the climate on Mars was much different at the time the valley networks were carved. It's hard to pinpoint when these valleys formed, but the abundant valley networks on the ancient cratered terrain in the southern hemisphere suggest that the warmer and wetter epoch of flowing water was between 3.5 billion and 4 billion years ago. This straddles the period of late heavy bombardment that occurred 3.8 billion years ago — the time when all the inner planets were subjected to intense cratering from debris left behind from the formation of the solar system.

This was a critical time because we have direct evidence that life on Earth was already well developed in the microbial sense by 3.5 billion years ago. (See "The Cosmic Origins of Life on Earth" by Christopher Chyba, November 1992.) It is hard to find sedimentary rocks older than this age that have not been destroyed by the active nature of Earth's surface. But one set of partially destroyed rocks from 3.8 billion years ago contains evidence that strongly suggests life at this earlier time. Biologists think this life arose in liquid-water environments, but they do not know how long the life-creating process required. From the ages of the


MARS
CO₂, N₂ atmosphere
Meteor bombardment
Formation of Tharsis
Diminishing volcanic activity
Valley networks ?
Period of warm, moist conditions ?
4.5
4.0
3.5
3.0
2.5
CO₂, N₂ atmosphere
Meteor bombardment
Definite evidence for life
EARTH
Oldest rocks

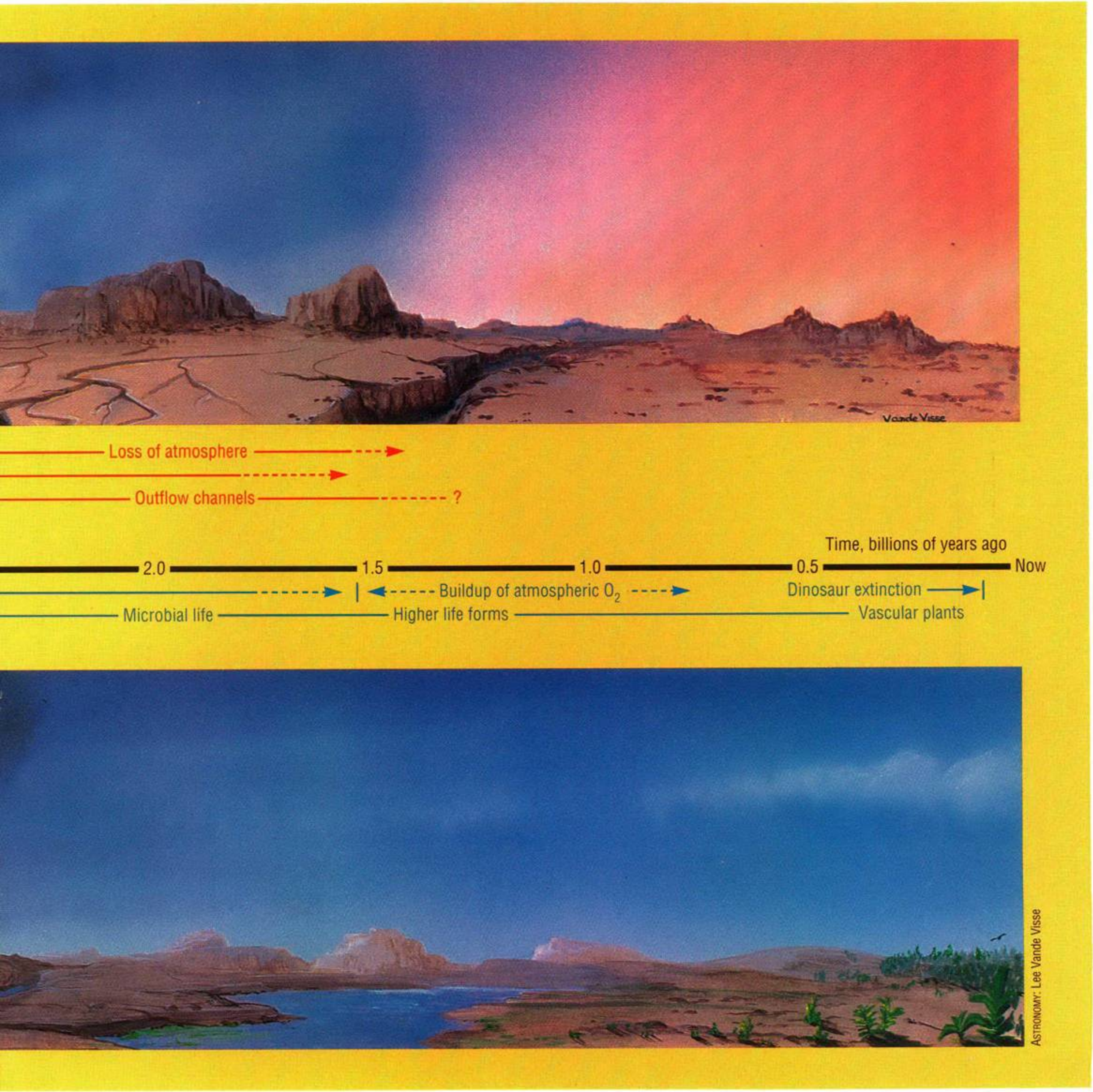
earliest life, we can confidently say that it took no longer than about half a billion years. But it could have been much shorter, conceivably only millions of years.

So life on Earth seems to have arisen at the same time that water, the quintessential requirement for life, flowed in the valley networks on the surface of Mars. That's why planetary scientists think life might also have developed on Mars and why they want to search for fossil evidence of this life.

Life under a Greenhouse?

If Mars had a warmer, more clement climate in the past, what happened to it? Current theories suggest that Mars started off with a thick atmosphere of carbon dioxide (as thick as or even thicker than Earth's present atmosphere) that outgassed from the planet's interior. This atmosphere acted much like a greenhouse by trapping infrared radiation, which kept the surface warm and allowed liquid water to flow.

But when the atmospheric carbon dioxide combined with liquid water, it formed a weak acid, carbonic acid. This reacted with rocks on the surface, transforming the carbon into carbonates such as limestone and dolomite. These carbonates then precipitated on the floors of oceans and lake basins. Eventually all the carbon dioxide in Mars' atmosphere


Vande Visse
Loss of atmosphere
Outflow channels
?
Time, billions of years ago
2.0
1.5
1.0
0.5
Now
Buildup of atmospheric O_2
Dinosaur extinction
Microbial life
Higher life forms
Vascular plants

ASTRONOMY: Lee Vande Visse

was exhausted, and the planet's surface became the cold, dry place we see today.

The same process would have happened on the early Earth (which we also think was kept warm by a thick atmosphere of carbon dioxide) except that on Earth, plate tectonics helped recycle the carbon dioxide. When two plates collide, one dives beneath the other in a process called subduction. Subduction carries the carbonate deposits to great depths, where heat decomposes the carbonates back to carbon dioxide gas, which then comes bubbling up in the volcanos created at the subduction zones.

Mars lacks plate tectonics, presumably because it is smaller and therefore radiated away its internal heat faster than it could generate it. With no long-term mechanism to recycle the carbon dioxide back into the atmosphere, the climate deteriorated and became uninhabitable. (Some recent studies, however, suggest that Mars may have regenerated a thick atmosphere when hot lava flowed over the carbonate deposits and released the trapped carbon dioxide. The thicker atmosphere could have ushered in a return to relatively warm, wet conditions for a period of a few hundred million years.)

Now the key question arises, How long did Mars have liquid-water habitats suitable for life? The answer

to this question has two parts: How fast did Mars lose its carbon dioxide atmosphere, and how cold can it get before liquid-water habitats suitable for life disappear?

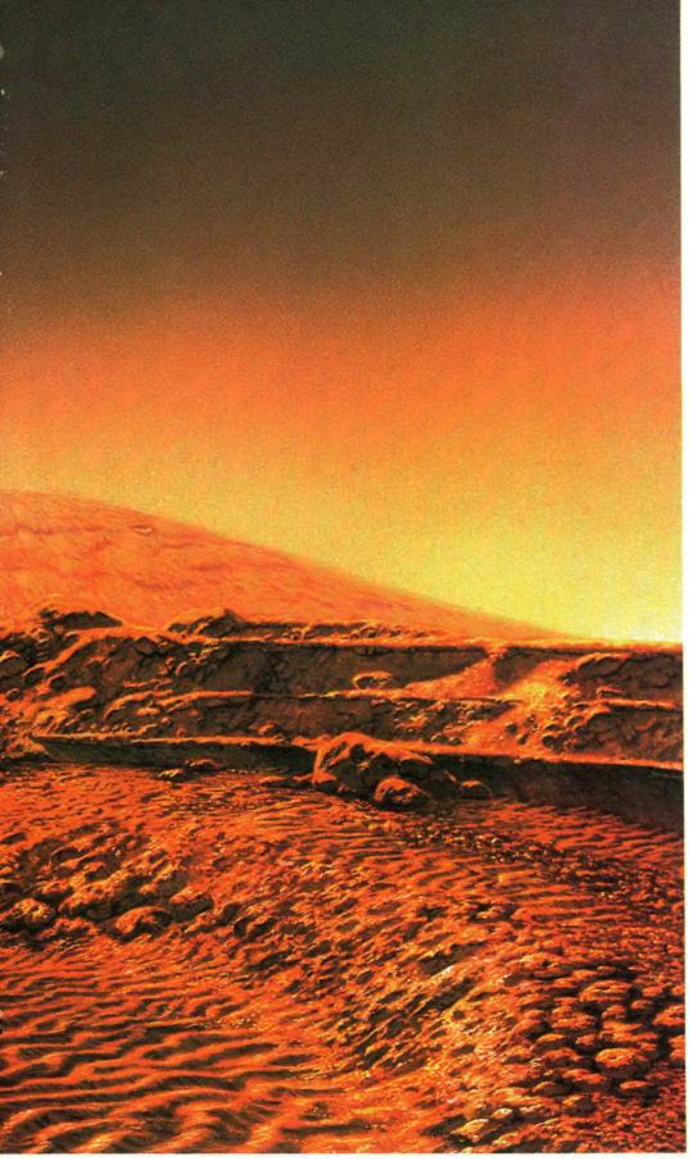
We now think that the initially thick atmosphere of carbon dioxide on Mars disappeared rapidly during the warm, moist conditions that existed prior to and perhaps after the end of the heavy bombardment about 3.8 billion years ago. But the rapid removal of the atmosphere lasted only as long as there were bodies of liquid water to absorb the carbon dioxide. As the atmosphere thinned, the greenhouse effect abated and temperatures eventually fell below freezing. From that point on, the carbon dioxide would have been removed ever more slowly and further drops in temperature also would have proceeded more slowly. This leads to the second part of the question, life's ability to survive increasingly frigid conditions. Ecosystems found in ice-covered lakes in the dry valleys of Antarctica provide a clue.

A Bit of Mars on Earth

These Antarctic valleys are extremely cold and dry. The average temperature is a chilly –20° Celsius and the net precipitation averages less than two centimeters per year. It never rains, and during most years the valley floors receive just a light dusting of snow. Because they are so cold and dry, these valleys are considered the most Mars-like places on Earth. In fact, they are the most Mars-like places anywhere in the solar system — outside Mars, of course. At first glance, the dry valleys appear profoundly lifeless. And in fact their soils are so bereft of life that in the early 1970s they were used as analogs to the Martian soil during planning for the Viking biology experiments. Yet surprisingly, two major ecosystems exist within this barren, frigid desert.

In one, algae dwell under the perennial ice cover of the lakes on the valley floors. Despite ice thicknesses of three to six meters, enough sunlight passes through so the algae can photosynthesize. Nutrients and dissolved air flow into the lakes with water from the nearby glaciers that melt on the few warm summer days. In the other ecosystem, lichen lie just below the surface of certain sandstone rocks on the mountain slopes overlooking the valley floors. The rocks warm to well above freezing in the summer sunlight, retain moisture generated during the rare snowfalls, and shield the lichen against wind and ultraviolet radiation. Both ecosystems thrive during the few days each summer that liquid water is present.

These Earthly ecosystems prove that even if the average annual temperature is –20° Celsius, microbial life can prosper as long as even transient sources of liquid water exist. So *it's not the average temperature* that matters: It's the ability of Mars to create meltwater during the heat of summer. Using the Antarctic systems



COLD, DRY, AND INHOSPITABLE — that's Mars now, but there could still be a record of life if primitive organisms formed there billions of years ago.

Paul Hudson

as a guide, my colleagues and I have estimated that the duration of liquid habitats on Mars, those able to sustain life similar to that seen in the Antarctic dry valleys, was from 500 million to a billion years. Although we don't know precisely how long it took life to evolve on Earth, we think it was much less than a billion years.

Just maybe life evolved on Mars too. And if it did, there's a good chance that evidence for this early life may still exist, because over two-thirds of the Martian surface is older than 3.5 billion years. The record of early Mars, unlike that of Earth, is still preserved, waiting to be examined. It's ironic that a planet like Earth has destroyed the past record of life as it has maintained that life. Although the Martian surface soil appears to have been altered by reactive chemicals, this should not have destroyed organic or fossil evidence for life deeper down. Thus, while Mars probably has no life on it today, it could hold the best evidence we have as to how life begins in an Earth-like environment.

Hunting for Martian Fossils

Where would we look for fossils on Mars? The best locations would be places where there had been a standing body of water, such as a lake. A lake is not only a good place to live when conditions get cold, as is shown by the Antarctic dry valleys, but also a good place to die if you want to leave a record of your existence. When something dies in a lake, its body can settle to the bottom and be preserved in the sediments, awaiting exhumation by scientists.

Large lake beds have the added benefit of being relatively easy for spacecraft to land in. The late Harold Masursky of the U. S. Geological Survey was the first to suggest that the deposits seen in some of the canyons of the Valles Marineris could be prime sites for searching for Martian fossils.

The Viking results strongly suggest that no life exists on the surface of Mars today; it is too dry, too cold, and too oxidizing. But the Viking landers only scratched the surface — both literally and figuratively — in their search for life on Mars. Underneath the surface it may be possible for liquid water to exist and persist for long periods of time. After all, the outflow channels offer direct evidence that liquid water has been present in subsurface aquifers on Mars throughout most of its history.

Lifeforms in such an aquifer could not obtain their energy from sunlight as photosynthetic organisms do on Earth. Instead, they would have to utilize chemical energy. Such chemosynthetic organisms appear on Earth in the form of methanogens, which consume molecular hydrogen and carbon dioxide and produce methane as a waste product. So a habitat for life on Mars could be based on a geothermal source of hydrogen together with atmospheric carbon dioxide and subsurface liquid water. We don't have any direct evidence that such a salubrious underground niche exists, but we can't rule it out either. The high-resolution camera and the thermal emission spectrometer on Mars Observer may help locate such geothermal hot spots — Martian Yellowstone Parks — if they exist.

To get to the evidence for life on Mars we will have to dig deep into the surface. This is true whether we search for fossil evidence of past life or try to reach present forms in their subsurface habitats.

The fascination with the search for life on Mars, both dead and alive, reflects humankind's overall quest for life beyond Earth. While our theories suggest that life should be widespread in the universe, we have no hard data to support this. We've detected no alien signals and found no oxygen-rich planets around distant stars. In our own solar system, Earth appears to be the only planet with an active biosphere. In fact, the evidence for liquid water on Mars, albeit billions of years ago, is the best clue we have to life elsewhere, and the search for life there is the first real test of our theories of how life began.

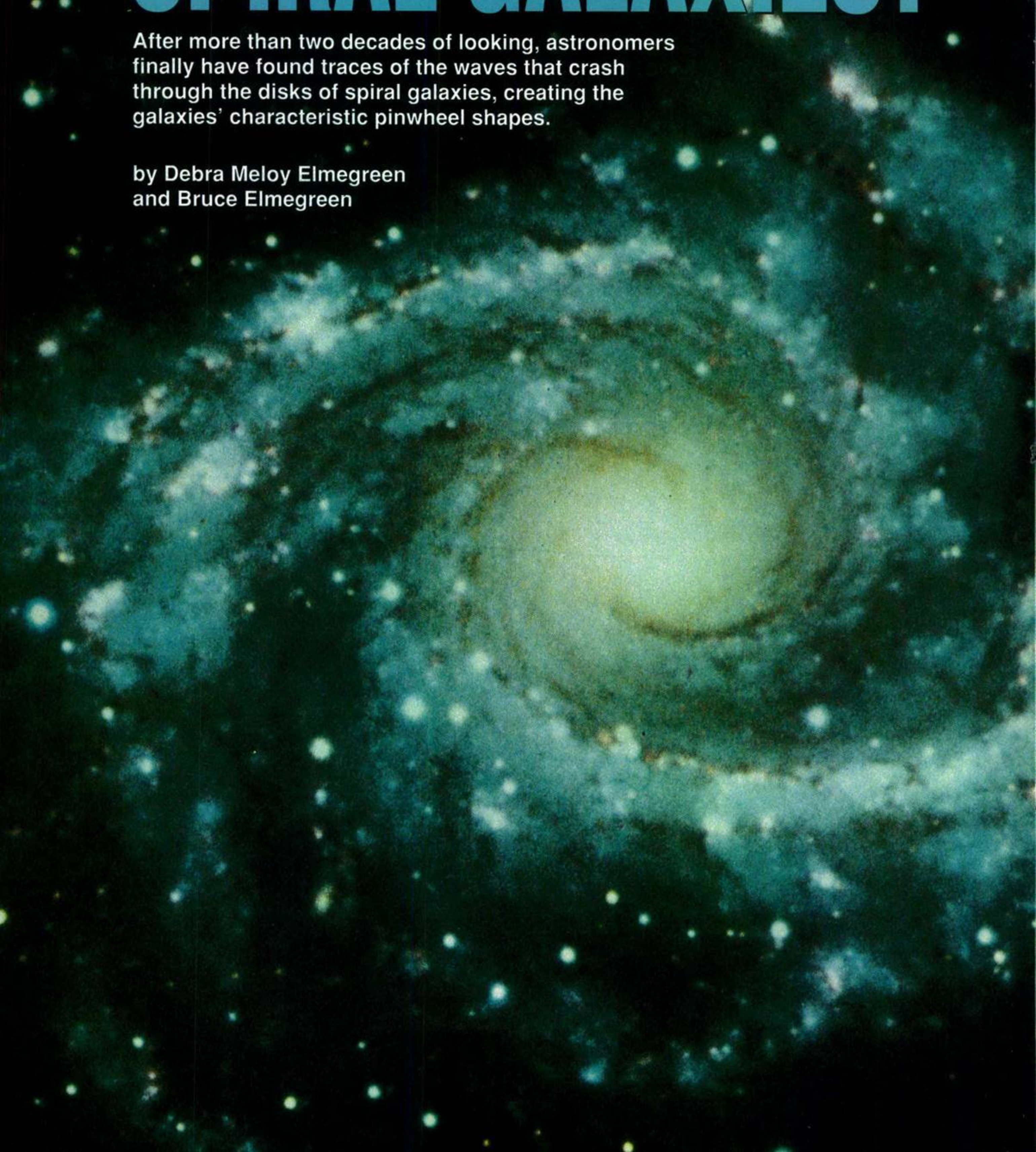
Earth and Mars led remarkably similar lives during the first billion years of their existence, and everything we know about how life originated on Earth hints that life likely arose on Mars too. Whether we find life on Mars or not, the search for it promises to teach us more about our origins and the origin of life in the universe. □

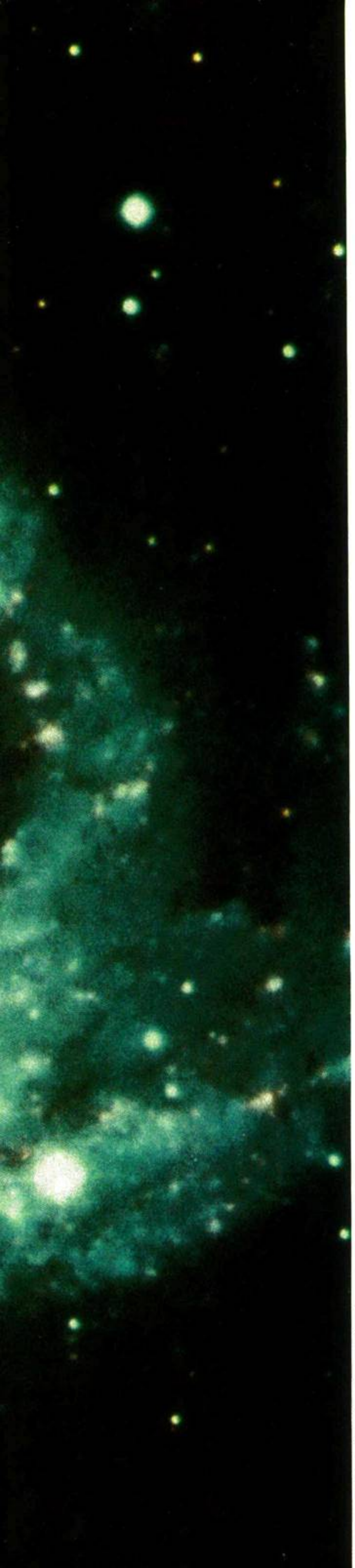
Christopher P. McKay is a planetary astronomer in the Space Sciences Division at NASA's Ames Research Center in Moffett Field, California.

WHAT PUTS THE SPIRAL IN SPIRAL GALAXIES?

After more than two decades of looking, astronomers finally have found traces of the waves that crash through the disks of spiral galaxies, creating the galaxies' characteristic pinwheel shapes.

by Debra Meloy Elmegreen
and Bruce Elmegreen





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Say the word "galaxy" and everybody — including astronomers — imagines a spiral galaxy. Of course, other types of galaxies exist, such as ellipticals and irregulars. But the arms that arc gracefully through the disks of spirals make these galaxies the most picturesque of all. The arms also make spirals the most enigmatic.

Spiral galaxies are bright, glittering deceivers. Like con artists working a fairground shell game, spiral galaxies divert your attention with the beauty of their swirling arms, while throughout their broad, thin disks, the real action goes on. For over a century, astronomers have theorized about what creates the pinwheel arms of spirals. Now observers think they have finally found evidence of the mechanism that shapes these galaxies: long-lived density waves that bounce back and forth in the disk.

Density waves act in some ways like waves on a lake. They sweep up matter into one location, leaving less matter nearby. But unlike lake waves driven by wind, the waves that shape a spiral arise from gravitational pulls within the galaxy. And unlike the patterns of lake waves that anyone can see, the subtle patterns of galactic waves long resisted astronomers' efforts to detect them.

When you glance at an image of a spiral galaxy like NGC 2997 (opposite), it's tempting to think the arms of the spiral directly trace the waves. As astronomers are now learning, the waves in a spiral overlap each other to form a more complex pattern that hides in the details of the arms' structure.

Finding evidence for density waves in spirals wasn't easy. First, astronomers had to rethink the way they classify galaxies by their shape. Then they had to process telescopic images of spirals in a new way to enhance their arms.

Spirals — the Inside Scoop

The Irish astronomer Lord Rosse first observed the structure of a spiral galaxy when in 1845 he viewed the Whirlpool Galaxy (M51) with his 72-inch reflector. Since then researchers have found that spiral galaxies account for about one third of the estimated 100 billion galaxies in the observable universe. Most of the rest are elliptical galaxies, which range in shape from nearly round to cigarlike.

Besides their numbers, spirals and ellipticals have other differences. Ellipticals have little or no gas and dust, which makes them incapable of forming stars. Spirals, on the other hand, have large amounts of gas and dust and produce a few new stars each year. Elliptical galaxies have more stars concentrated at their center than at the outer edges but otherwise have little structure. Spirals, however, show three distinct regions: a central bulge, a nearly spherical halo, and a flattened disk.

The central bulge typically spans a few thousand light-years. Because the bulge is basically round and contains old, reddish, low-mass stars, it resembles an elliptical galaxy. At the very center of a galaxy is the nucleus. Recent Hubble Space Telescope results lead astronomers to believe that the nuclei of some galaxies contain a mammoth black hole.

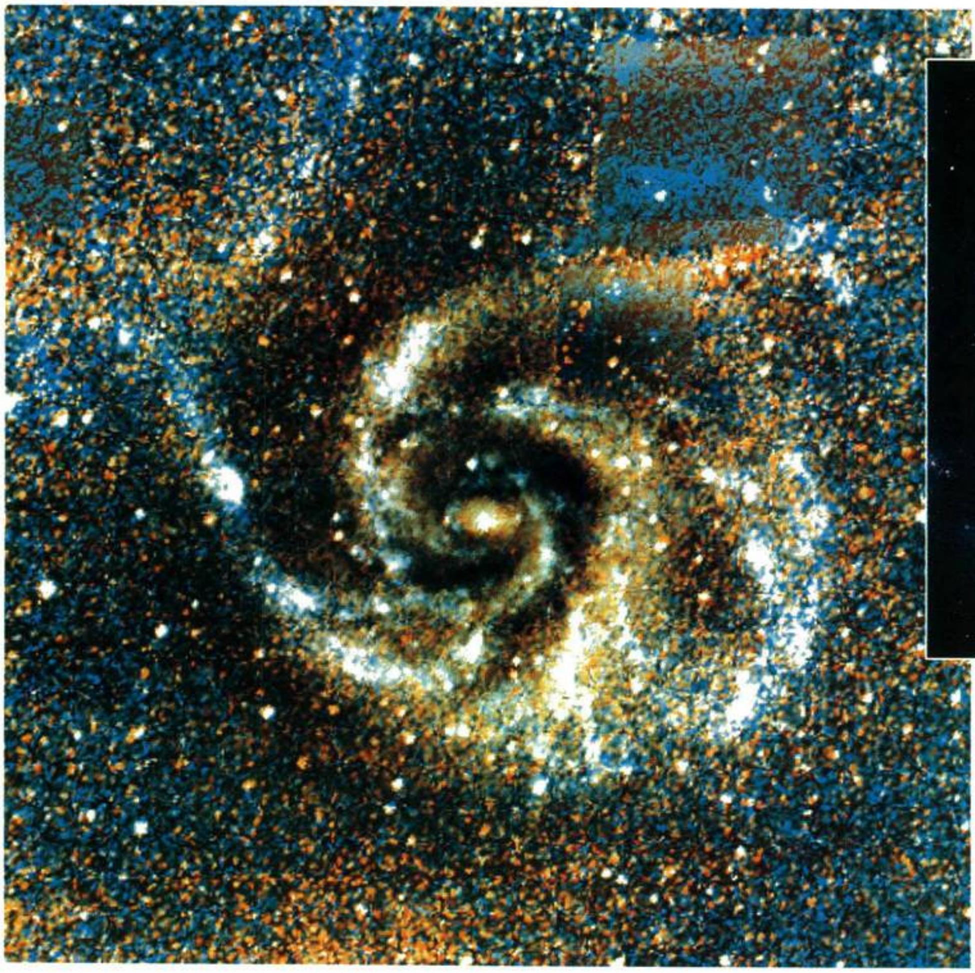
The halo of a spiral surrounds the disk and contains old stars similar to those in the bulge. Perhaps most of the stars in the halo lie in globular clusters, groups of a hundred thousand stars. The halo stars formed out of dense pockets of gas soon after galaxies began forming, about a billion years after the big bang. They retain the original spherical shape of the collapsing gas cloud that formed the galaxy.

Inside the stellar halo, the disk contains most of the galaxy's stars and presents the galaxy's characteristic spiral shape. The disk is flat because the spin of the original gas cloud prevented it from collapsing equally in all directions. Our Galaxy, which is typical of large spirals, has about 200 billion stars spread mostly through its disk, which is 100,000 light-years across and about 3,000 light-years thick.

As we look out from our position in the disk of the Galaxy, we see many stars along the plane of the disk but fewer stars perpendicular to it. When we look at the band of light in the night sky called the Milky Way, we are seeing the plane of our Galaxy.

There's more to the disk than just stars. The interstellar medium, or stuff between the stars in a galaxy, is mostly hydrogen gas. Gas accounts for about 5 to 20 percent of the visible

GRACEFUL SPIRAL ARMS DOMINATE OUR VIEW of spiral galaxies like NGC 2997 in constellation Antlia. Density waves sweep gas and stars in and out of the arms that arc through the spiral's disk.



Debra and Bruce Elmegreen

Canada-France-Hawaii Telescope

INNER AND OUTER ARMS APPEAR with nearly equal contrast in this enhanced image (left) of M101 in Ursa Major. The view combines blue and infrared images to show light from both young and old stars. A visible-light photo (above) shows a normal view of the galaxy.

mass of a spiral galaxy, compared with less than 2 percent for ellipticals. Some of this gas diffuses through the galaxy, while other gas gathers into discrete clouds. These pockets of gas range from a few hundred solar masses in size to 10 million solar masses. The biggest clouds concentrate in or near the spiral arms; the smaller clouds scatter throughout the disk. Gas clouds are among the most important features of spirals because they are the birthplaces of stars.

From Gas Clouds to Stars

Collapsing gas clouds create stars with masses ranging roughly from one-tenth to forty times the mass of the Sun. Contrary to what you might expect, collapsing gas clouds favor making many small stars rather than one large star. Thus most stars in a galaxy are low-mass ones with temperatures under 5000 kelvins, which makes the stars appear orangish to reddish. Only a few stars contain much more mass than the Sun, but these powerhouses of energy have temperatures up to 40,000 kelvins and bluish-white colors.

Shining millions of times brighter than their low-mass cousins, high-mass stars dominate the light in a galaxy way out of proportion to their numbers. But although these bright stars often lie in the arms, they don't directly trace the density waves. That's because the waves don't directly cause star formation. Instead the waves merely sweep stars and gas in and out of the arms.

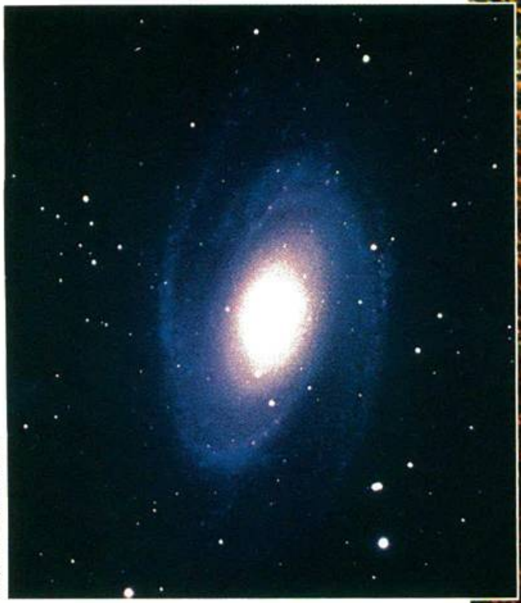
All spirals have the same components of bulge, halo, and disk, and share the trait of star formation, but their shapes differ. Some spirals have bigger bulges than others. The shape of the arms also differs, some being wound loosely around the central bulge, others more tightly. To keep track of these different bulge and arm shapes, astronomers long ago devised a classification scheme.

Fat yet Fast

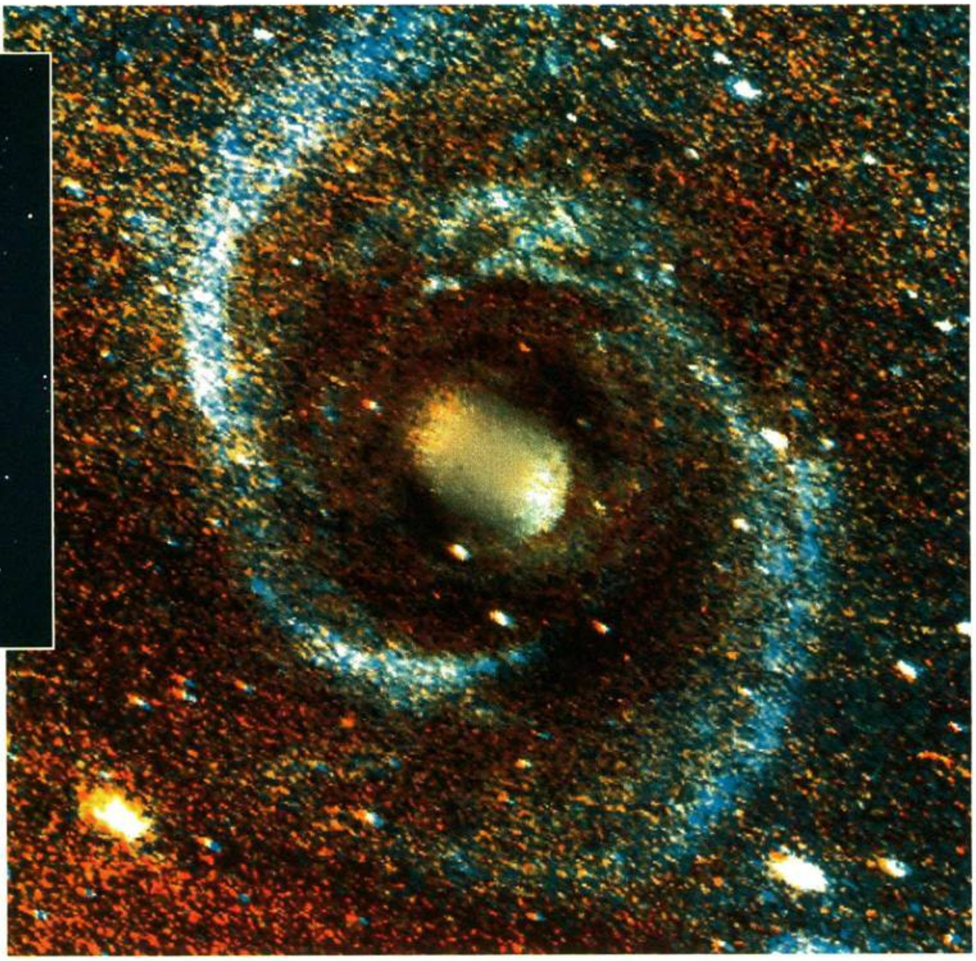
In the 1920s, Edwin Hubble first classified galaxies as S for spirals and E for ellipticals. He used two main criteria for subdividing spirals: the size of the bulge relative to the disk and the tightness with which the arms wrap around the bulge. Class Sa denotes galaxies with big bulges and tight arms, like the Sombrero galaxy (M104) in Virgo. Sc describes those with small bulges and more open arms like the Pinwheel galaxy (M101) in Ursa Major (above). Sb forms the intermediate type for galaxies like M81 in Ursa Major (opposite).

In addition, Hubble noted, some spiral galaxies have bar-shaped configurations. He distinguished these from the ordinary S galaxies by calling them SB, and subdivided them into a, b, and c, as before. SBa galaxies have bars that extend over one-third to one-half of the optical disk, whereas SBc galaxy have bars that reach only about one-fifth to one-third the disk size. Theoretical models indicate that the bar maintains its shape even after many rotations of the galaxy, much like a yardstick spun about its midpoint.

Since Hubble's work, other classification schemes have arisen, such as those developed by Sidney van den Bergh at the Dominion Astrophysical Observatory and Gerard de Vaucouleurs of the University of Texas. (De Vaucouleurs added subclass "d" for galaxies with extremely small nuclei, such as NGC 7793 on page 38.) But all these systems still describe only the general shape or brightness of the arms.



Tony and Daphne Hallas



Debra and Bruce Elmegreen

COMPUTER ENHANCEMENT REVEALS the symmetric wave patterns that create the arms of spiral galaxies. The image of M81 in Ursa Major at right has been stretched on a computer to make the galaxy appear as if it were viewed face-on instead of in its normal tipped orientation (above).

Astronomers have found that the general arm shape results from the orbital speed of stars in the disk. Stars and gas have nearly circular orbits in the disk, but Sa galaxies have peak orbital velocities (300 kilometers per second) that are much higher than Sc galaxies (100 km/s) of the same brightness.

To better understand how the arms form, we have developed a new classification scheme that addresses the details of the spiral arms.

Looking at Spirals in a New Way

The heart of our system lies in assessing how symmetric and continuous the arms are. We call galaxies like the Whirlpool Galaxy, M51 (see next page), that have long and symmetric arms "grand design." Galaxies like NGC 7793 (next page), with short asymmetric pieces that merely give the illusion of a spiral pattern, are called "flocculent" because of their fleecy appearance. Intermediate examples, such as NGC 613 (next page), showing characteristics of both flocculent and grand design galaxies, we call "multiple arm" galaxies. These galaxies have two symmetrical arms in the inner part of the disk, but their outer regions are highly branched and include many spiral arms and arm segments.

Overall, we find a galaxy's arm classification is independent of its Hubble type; each of the Sa, Sb, and Sc types can be flocculent, multiple arm, or grand design.

The details of arm structure depend partly on the presence of internal bars, as was first shown by John Kormendy of the University of Hawaii and Colin Norman of the Space Telescope Science Institute. Galaxies with grand designs tend to have either nearby companion galaxies or bars. When galaxies have both bars and companions, over 90 percent are grand design in type. (It appears that interactions between galaxies are often responsible for forming bars.) So isolated spiral galaxies tend to be flocculent whereas spiral galaxies in clusters, which have lots of neighbors and more possibilities for interactions, tend to have a grand design pattern.

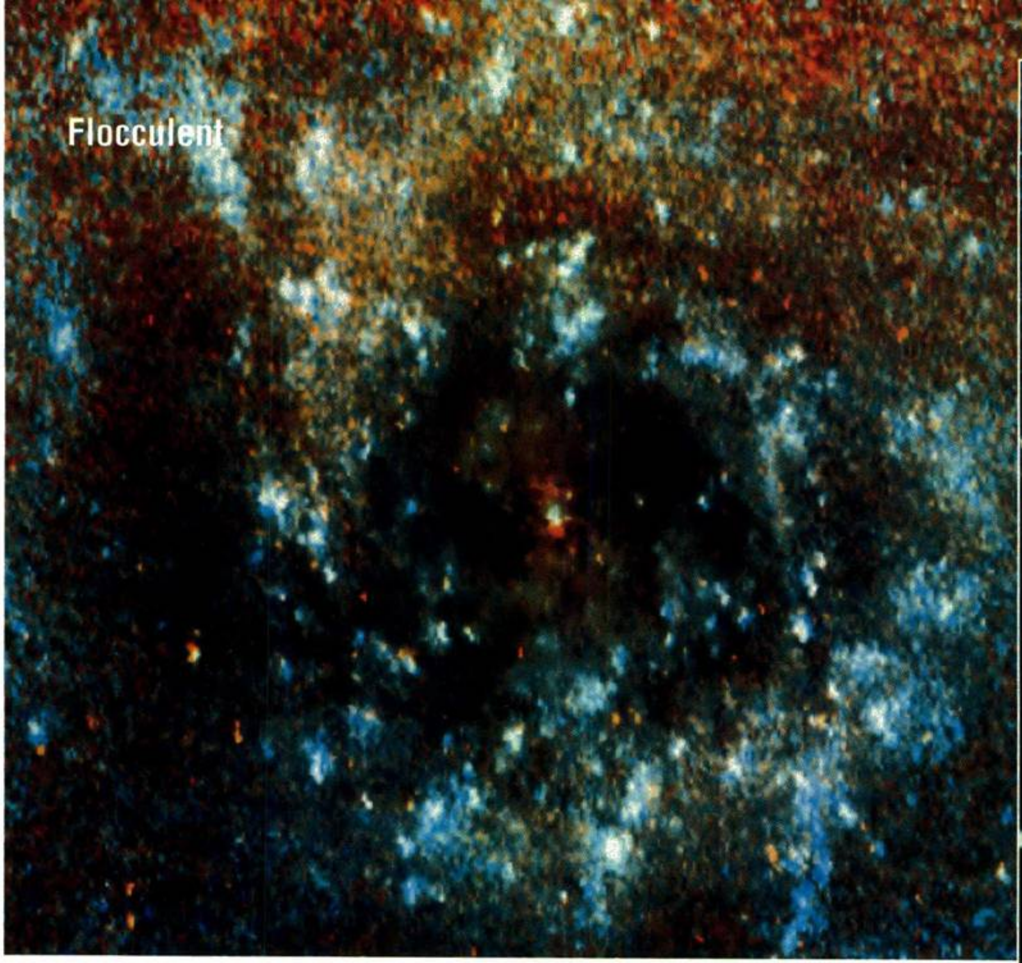
Analyzing arm structure is straightforward for galaxies viewed from above the disk, but most galaxies appear tilted to our line of sight. We can simulate looking face-on at them by stretching computer images until they appear round (since we know galactic disks are circular). We also enhance the images because the brightness of the disk falls off sharply from the center to the edge of the disk. Enhancing the images lets us examine both the bright inner regions and the faint outer regions with good contrast.

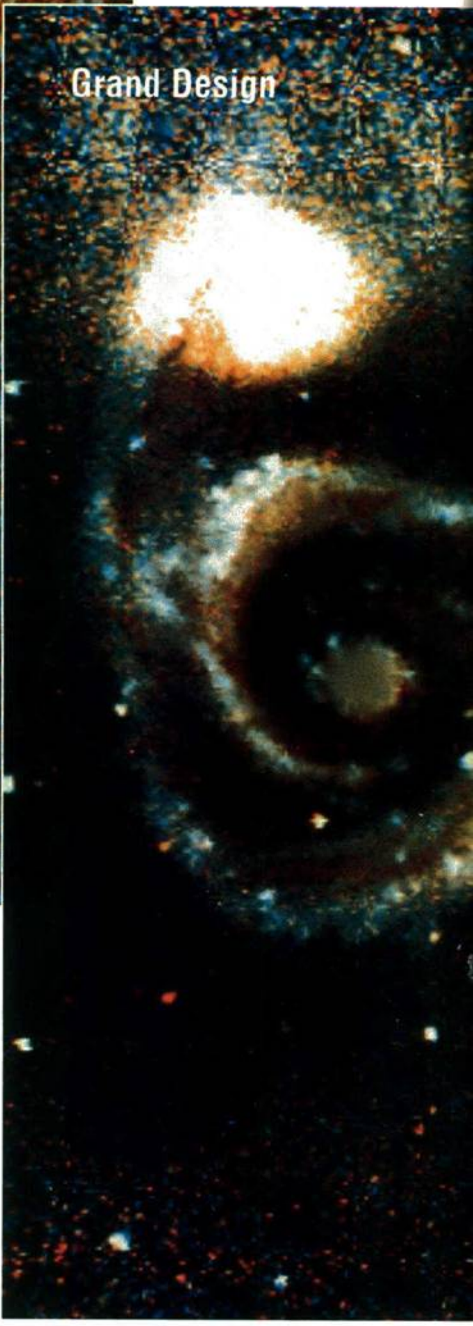
Remarkable structure that wasn't easy to see in the original images becomes obvious when enhanced. For example, in M81 (above) the two main arms start bright, become fainter partway out, and then become bright again in the outermost regions. This pattern, which we have noticed in several galaxies, forms the first solid evidence for the existence of spiral density waves.

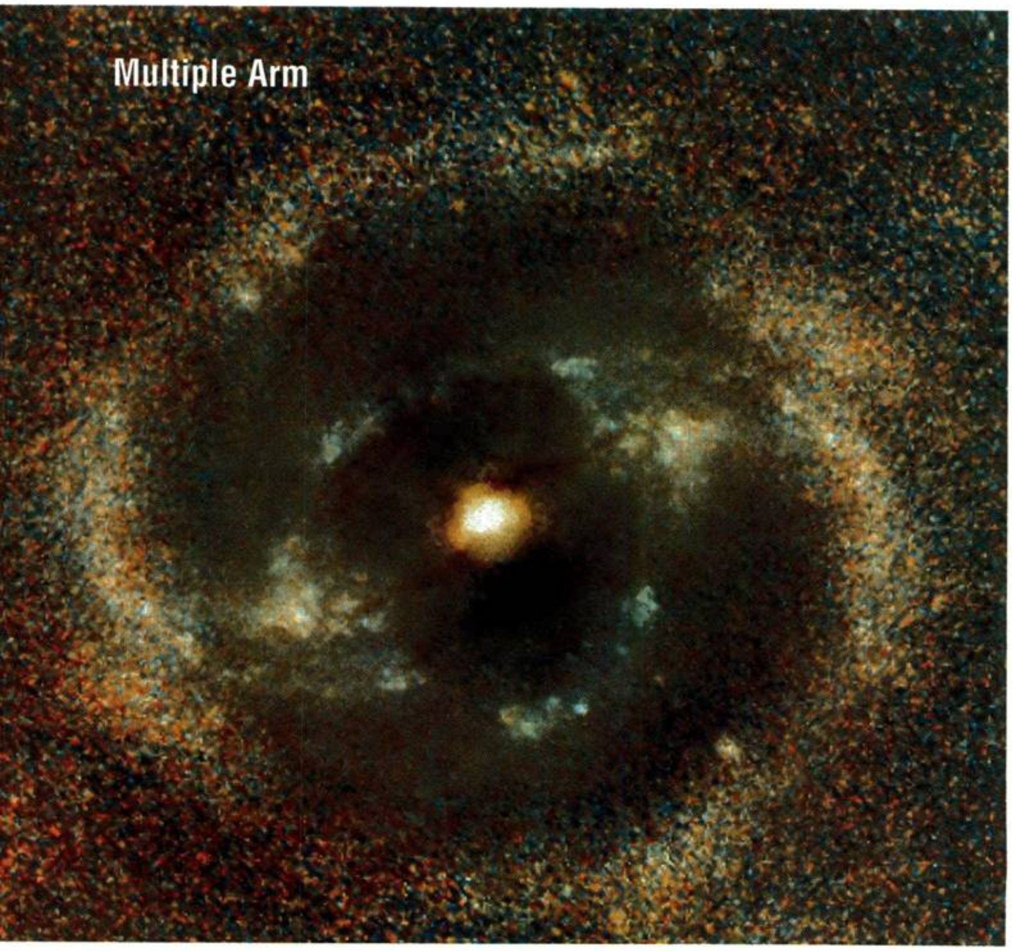
Doing the Wave

The theory of density waves dates back to the ideas of Bertil Lindblad of Sweden in the 1940s. They were elaborated upon in the 1960s by C. C. Lin of the Massachusetts Institute of Technology and Frank Shu of the University of California. Theorists continue to refine these ideas, which basically describe how a galaxy's

All images this page by Debra and Bruce Elmegreen



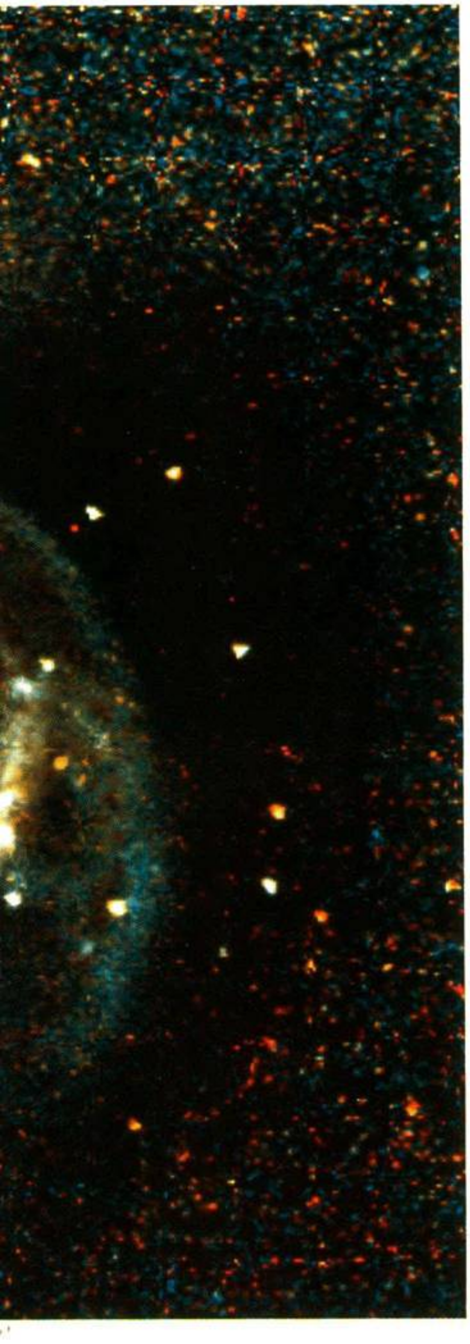




FLOCCULENT GALAXIES such as NGC 7793, an Sd galaxy in Sculptor, do not have large-scale density waves that organize the gas and stars in the disk into arms. Random regions of star formation give a broken arm appearance.

MULTIPLE ARM GALAXIES such as NGC 613, an SBb galaxy in Sculptor, have characteristics of both flocculent and grand design galaxies — symmetric arms and traces of random star formation throughout the disk.

GRAND DESIGN GALAXIES such as M51, the Sc-shaped Whirlpool galaxy in Canes Venatici, show symmetric arms. The arms glow with the light of young stars created by waves that compress the gas in the galaxy's disk.



gravity causes waves to ripple slowly through the matter in its disk. Wave crests temporarily concentrate gas and stars into regions that form the galaxy's arms.

As astronomers now see it, grand design and multiple arm galaxies have long, symmetric arms that are created by spirally shaped density waves. While individual stars may move in and out of the arms as they orbit the center of the galaxy, the wave pattern wheels around the disk at a constant rate. The relentless sweeping interaction of the wave with stars continuously piles up new gas and new stars to maintain the shape of the arm.

Flocculent galaxies seem to lack a global spiral density wave. Their short arms may result when star-forming regions, lying at different distances from the galactic center and orbiting at different speeds, temporarily line up to form an arc. This structure lasts only several tens of millions of years because the high-mass stars that illuminate the arm have short lives and rapidly fade from view. Computer simulations by Philip Seiden of the IBM Research Center and Humberto Gerola have shown how star formation can percolate through flocculent galaxies, creating the short, random arms characteristic of these galaxies.

Another difference between grand design and flocculent galaxies lies in the distribution of young and old stars through the galaxies. Flocculent galaxies appear different in red and blue light. Blue-light images show irregularly spaced arm segments created from newly formed stars, while red light shows a smooth disk of old, low-mass stars. The difference indicates that density waves haven't organized all the gas and stars in these galaxies.

In contrast, grand design galaxies have arms that stand out equally in red and blue light. This means that the density waves have organized all the gas and stars in the disk into a coherent pattern, and the exact nature of the waves determines the precise shape of the spiral arms.

Wobbling from Arm to Arm

Grand design galaxies also differ from multiple arm ones due to differences in the wave patterns within the galaxies. As each density-wave crest travels through the galaxy, it may encounter other waves. As the two pass through each other, they may add their energy or they may cancel, leading to a complex pattern of ripples through the disk. These wave patterns lead to the arm gaps and spurs and short spiral arm segments astronomers see in some galaxies.

Astronomers can trace these patterns by observing stars and gas. Stars and gas "wobble" about their nearly circular orbits around the galactic center because of the gravitational pulls of giant gas clouds and the spiral arms themselves. Astronomers call this periodic wobbling motion an "epicycle." If the time to complete one epicycle exactly matches the time it takes a star to go from one arm to the next, then a resonance develops. This is what happens when someone on a swing pumps her legs at just the right times to make the swing go higher. Resonance in a galaxy means that stars soak up gravity wave energy and their epicycles become larger.

In galaxies with well-defined arms, the arms have an inner and outer limit beyond which they don't extend. (Sometimes the arms extend all the way into the galaxy's nucleus.) Inside and outside of these limits the galaxy's stars and gas completely absorb the energy of the spiral density waves and prevent the waves from going beyond to form arms.

Grand design galaxies have very prominent symmetric structures, with one side mirroring the other all the way from the inner limit to the outer. In these galaxies, each star completes its epicycle exactly once in the time between its encounters with each of the two spiral arms. This means it completes two epicycles during each orbit around the galactic center. Multiple-arm galaxies have prominent three-arm structures over part of their disks, indicating that three epicycles occur as each star completes its orbit around the center of the galaxy.

The rotation speeds of the gas and stars in the galaxy interacting with the angular speed of the wave pattern uniquely determine a galaxy's resonance pattern and thus the locations of its spiral arms. If researchers can find or guess the location of any one resonance (such as where the spiral arms end), they can then calculate the positions of the other resonances. So from prominent arm features, astronomers can discover the type of density wave pattern in any spiral galaxy.

So far astronomers have just glimpsed the barest of facts about density waves and how they shape spirals. They still need observations of many more galaxies in order to sort out the details of star formation and how these details relate to the presence of density waves. But it seems that spiral arm theories and observations finally are beginning to fit together, which has importance beyond explaining the shape of galaxies. These studies also form a key stepping stone for exploring how galaxies have evolved since their creation billions of years ago. ☐

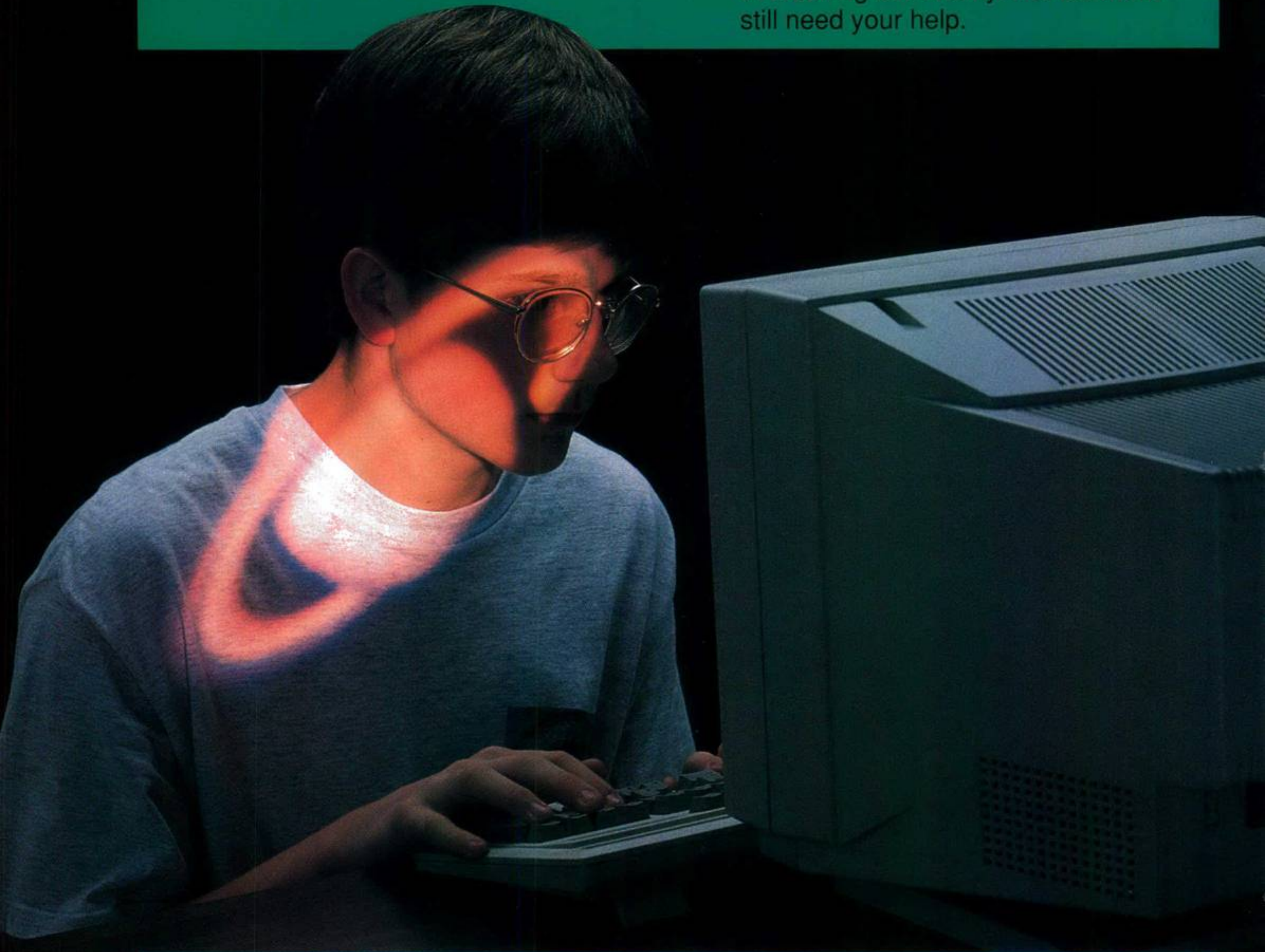
Debra Meloy Elmegreen is an astronomer at Vassar College and Bruce Elmegreen is an astronomer at IBM's T. J. Watson Research Center in Yorkstown Heights, New York. They both specialize in the study of galaxies.

ASTRONOMY IN THE CLASSROOM

BUILDING ASTRONOMY'S FUTURE

by David Bruning

A peek into classrooms across the country shows many innovative ways of teaching astronomy. But teachers still need your help.



It's the fourth quarter in the Super Bowl. The New York Giants have the ball on the Los Angeles Raiders' 10-yard line. The Giants are six points behind, and it's fourth down and one yard to go. While the coaches decide whether to go for the first down or try a field goal, the crowd in the stands and millions of television viewers simultaneously scream for the Giants to go for it and for the Raiders to stop them.

Can you imagine such an impassioned response to a science experiment or a lecture in a science class? Hardly. To most students, science appears as a boring collection of dry facts.

To change the student's perception, a growing number of educators are presenting science as the hands-on research activity it is, involving students in new ways. Because of space I can't tell you about all of them, but this sampling of astronomy programs should give you an idea of the wonders being worked at schools across the country. And not all of these programs started with teachers; some originated with amateur astronomers.

Making Students Players

We know from studies of how people learn that many students learn best by doing. Besides, science is a

PLAYING THE GAME

A research class is an ideal platform from which high school students can truly learn about science. There are no worksheets, tests, or homework assignments. Instead the course is discovery oriented and entirely hands on because science is about exploring, not stuffing students' heads as if they were pillows. The focus on real research involves students in the entire spectrum of activities that forms the scientific process.

Of course teachers have used group projects in the classroom before. But usually the teacher directs the course and, more importantly, knows the answer to the problem. In my research course at Sahuaro High School in Tucson, Arizona, I act as a guide, a resource person, and a co-worker. But I, like the students, am ignorant of the final answers. We must explore, discover our own truths, and arrive at fresh understandings instead of reconfirming old ones. I have been fortunate to have Don McCarthy of Steward Observatory assist me as a scientist-mentor.

Many scientists are eager to have help analyzing large data sets. For example, my class is working now on Venus data obtained by the Magellan spacecraft and stored on CD-ROMs. The students are locating and measuring the diameters of small volcanic cones to see if position or size correlates with elevation on the Venusian surface. The CD-ROMs have enough data for 1,200 students to analyze. A lab full of scientists would find this task daunting, but a network of 40 high school classrooms could do it in a semester.

After analyzing the data, my students create a class paper and a poster to present at a scientific conference. The students talk with the scientists and defend their research. They show great pride in holding their own with the pros.

The end result of this course is not scientific fact but a deeper understanding of science and how it works. The student's view that research is about looking up answers in a library changes to research is "about solving problems and getting at new ideas" and "the constant struggle against the unknown." — *Jeff Lockwood*

Jeff Lockwood

HIGH SCHOOL STUDENTS at Sahuaro High in Tucson, Arizona, measured craters to show that oceans of water once covered the northern plains of Mars.

"verb" — it's largely about discovering, not solely about what others have discovered. So students should participate in the scientific process and thereby take ownership of their learning.

Standard lab exercises do not always involve students or provoke their curiosity about the universe. Take the classic physics lab exercise of measuring the acceleration of an object due to gravity. This doesn't excite most students because, as one student put it, "After all, hasn't gravity already been measured a zillion times by students and scientists? Why should I be thrilled about yet another determination of a boring number?"

Jeff Lockwood, a teacher at Sahuaro High School in Tucson, Arizona, describes science as a game and students as its players. Football and baseball players would never practice for 12 years, dreaming of sitting on the bench. They practice plays and develop skills so they can play. And that's what we need in our classrooms — programs that turn students into players.

Jeff has done just that, bringing real research programs into his classroom. His students don't follow a textbook on astronomy, because understanding science is more than getting through the book. They focus narrowly on a given topic. Jeff's students truly learn what science — and learning — is all about. (See "Playing the Game" above.)

Many astronomers across the nation are beginning to share their data and observatories with teachers and students. Lowell Observatory, in Flagstaff, Arizona, operates its 31-inch telescope on behalf of a group of 12 colleges to help form the National Undergraduate Research Observatory. (See "A New National Observatory" on the next page.) The Mount Wilson Institute, in Pasadena, California, is converting a 24-inch telescope for educational purposes. Students can phone in requests for observational data, paying a nominal fee for the use of the automated telescope.

Data in the past were difficult to come by. Planetary data obtained by spacecraft were stored on magnetic tape, but most schools didn't have the computer equipment needed to read the tapes. The recent development of the CD-ROM has changed that.

Voyager, Magellan, and Viking data are now available on low-cost ($6) CD-ROMs, opening a wealth of data on Venus, Mars, Jupiter, Saturn, Uranus, and Neptune. Other CD-ROMs let students explore stars and galaxies. (See AstroBytes in the January 1993 issue.) CD-ROM drives now cost less than $300. Many astronomy clubs have donated computer equipment to their local schools. Clubs can continue to help by adding a CD-ROM drive and some CD-ROMs to their local school's computer.

The Imaging Revolution

Computers provide many powerful learning opportunities for students. Many programs let students explore astronomical phenomena, not just memorize preset scripts containing facts. For example, David Earley, a student at Satellite High School in Satellite Beach, Florida, describes his experience with the TS-24 telescope simulator developed by Crystal Lake Observatory in Florida. He explored

ASTRONOMY: Chris Becker and Darla Gawelski

A NEW NATIONAL OBSERVATORY

Mike DiVittorio

Since 1990, astronomy students from around the nation have been able to conduct their own observing projects at the National Undergraduate Research Observatory. On a typical night you may find undergraduates from the University of Oklahoma taking images of supernovae in distant spiral galaxies, a student from Denison University in Ohio recording the light variations of an X-ray-emitting binary star, or a group from Gettysburg College in Pennsylvania watching a faint asteroid move across the screen of a computer monitor. Most students and faculty come on observing runs of a few days or a week, often during school vacations, and take their data home to use in thesis projects and faculty-student research papers.

At NURO, students use a 31-inch telescope that sits on Anderson Mesa, outside Flagstaff, Arizona. This is one of the prime observing sites in the southwest, with clear dark skies. The telescope has exquisite optics, has a CCD camera and other instruments, and is computer controlled from a warm room adjacent to the dome.

A consortium of 12 colleges and universities formed NURO — members include Ball State University, Benedictine College, Central Michigan University, Colorado College, Denison University, Dickinson College, Franklin and Marshall College, Gettysburg College, Northern Arizona University, the University of Nevada at Las Vegas, the University of Oklahoma, and Western Connecticut State University. Northern Arizona University administers NURO operations and Lowell Observatory provides the use of the telescope and site. Each summer NURO sponsors a concentrated "research experience" program, funded by a National Science Foundation grant, in which students work on observing projects under the supervision of professional astronomers from Lowell Observatory and schools in the NURO consortium.

"NURO provides a unique opportunity for students to get a taste of what it means to really do astronomy," says Kathy DeGioia Eastwood, an astronomer at Northern Arizona University and director of NURO. "And hands-on research, I think, is the best way to learn." Not all students who come to NURO become professional astronomers. But they all come away with an unforgettable experience in science. — *Laurence Marschall*

STUDENTS EXPLORE MARS

U. S. Geological Survey

Planets and the excitement of space exploration. Put the two together and you have a winning program, one that kids can relate to.

That's just what the Planetary Society and Washington University in St. Louis have done by creating MarsLink, a three-year project to bring the discoveries of the Mars Observer spacecraft to the classroom.

Once data from Mars Observer start coming in, students in grades 6 through 12 will use spectral data from the spacecraft to identify minerals on the Red Planet's surface, measure the heights of surface features using the laser altimeter, and use images to monitor ice at the polar caps. Or perhaps they will track moving clouds to determine wind speeds and directions. Other students might watch sand dunes to see how they change as storms race across Mars.

A preview kit that uses Viking data is already available for classroom use, including exercises on Martian seasons and climate. As data rolls in from Mars Observer, the MarsLink team of astronomers and educators will develop new activity kits.

Daily updates from planetary scientists on NASA's Spacelink electronic bulletin board will let students follow discoveries. And a Mars data specialist at Washington University will be on call to answer questions from students and teachers.

PLACES TO CONTACT

for more information about programs mentioned in this article

Jeff Lockwood
Sahuaro High School
545 N. Camino Seco
Tucson, AZ 85710

Director
Mount Wilson Institute
740 Holladay Road
Pasadena, CA 90024

National Undergraduate Research Observatory
Dr. Kathy DeGioia Eastwood, Director
Northern Arizona University
Department of Physics and Astronomy
Flagstaff, AZ 86011-6010

Project Astro
Astronomical Society of the Pacific
390 Ashton Avenue
San Francisco, CA 94112

CLASSROOM ACTIVITY KITS

MarsLink
The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106

Partnership in Astronomy and Hands-On Astrophysics
American Association of Variable Star Observers
25 Birch Street
Cambridge, MA 02138-1205

COMPUTER PROGRAMS

Center for Image Processing in Education
3620 N. Allwood Place
Tucson, AZ 85715

Contemporary Lab Exercises in Astronomy
Department of Physics
Gettysburg College
Gettysburg, PA 17325
(717) 337-6028

Crystal Lake Observatory's TS-24 is distributed by
Santa Barbara Instrument Group
1482 East Valley Road, Suite J601
Santa Barbara, CA 93108
(805) 969-1851

Dance of the Planets
ARC Science Simulations
P.O. Box 1955A
Loveland, CO 80539
(303) 667-1168

Orbits
Academic Software Library
Campus Box 8202
North Carolina State University
Raleigh, NC 27695-8202
(800) 955-8275

TEACHER WORKSHOPS

UT-SPICA
Department of Physics and Astronomy
University of Toledo
Toledo, OH 43606

Project SPICA
Center for Astrophysics
60 Garden Street
Cambridge, MA 02138

TEACHER NEWSLETTERS

Association of Astronomy Educators
5103 Burt Street
Omaha, NE 68132

Educational Horizons
NASA's newsletter for teachers
NASA Education Division
Mail Code FEP
Washington, DC 20546

NASA's Spacelink
electronic bulletin board for teachers available over the Internet computer network at spacelink.msfc.nasa.gov or by modem (205) 895-0028, 8/N/1 carriage returns or line feeds but not both
log in as NEWUSER; password is NEWUSER

The Universe in the Classroom
(a teaching newsletter)
Astronomical Society of the Pacific
390 Ashton Avenue
San Francisco, CA 94112

NASA REGIONAL CENTERS

contact the teacher resource center nearest you for slides, photos, and other resources

AK, AR, CA, HI, ID, MT, NV, OR, UT, WA, WY
NASA Ames Research Center
Teacher Resource Center
Mail Stop TO-25
Moffett Field, CA 94035
(415) 604-3574

CT, DE, DC, ME, MD, MA, NH, NJ, NY, PA, RI, VT
NASA Goddard Space Flight Center
Teacher Resource Laboratory
Mail Code 130.3
Greenbelt, MD 20771
(301) 286-8570

FL, GA, PR, VI
NASA John F. Kennedy Space Center
Educator Resources Laboratory
Mail Code ERL
Kennedy Space Center, FL 32899
(407) 867-4090

CO, KS, NE, NM, ND, OK, SD, TX
NASA Johnson Space Center
Teacher Resource Center
Mail Code AP-4
Houston, TX 77058
(713) 483-8696

KY, NC, SC, VA, WV
NASA Langley Research Center
Teacher Resource Center
Mail Stop 146
Hampton, VA 23665-5225
(804) 864-3293

IL, IN, MI, MN, OH, WI
NASA Lewis Research Center
Teacher Resource Center
Mail Stop 8-1
21000 Brookpark Road
Cleveland, OH 44135
(216) 433-2017

AL, AR, IA, LA, MO, TN
Alabama Space and Rocket Center
Teacher Resource Center
Huntsville, AL 35807
(205) 544-5812

MS
NASA Stennis Space Center
Teacher Resource Center
Building 1200
Stennis Space Center, MS 39529
(601) 688-3338

Inquiries about space exploration:
NASA Jet Propulsion Laboratory
Teacher Resource Center
JPL Educational Outreach
4800 Oak Grove Drive
Mail Code CS-530
Pasadena, CA 91109
(818) 354-6916

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how to find the distances to stars given only the stars' apparent magnitudes in three different colors.

New research? No, but that misses the point. David designed his own research and saw firsthand how astronomers obtain information about stars. This kind of exploration and revelation can't come from traditional textbook-driven classrooms. Students need to have the chance, as David has, to explore and follow their ideas.

Another area that has blossomed recently is image processing. We all like looking at images of astronomical objects, but conventional pictures convey a sense of "Look, but don't touch." As Larry Marschall of Gettysburg College in Pennsylvania says, "Now students can share in the excitement of digital imaging and gain a greater appreciation of the scientific enterprise as a whole."

Helping with the image revolution is the CCD camera. Conventional photography required perfect weather, long nights at the telescope with restless students, and messy darkrooms with lengthy explanations of the development process. With CCDs students can get nearly instant results and concentrate on using the images to study stars, planets, nebulae, and galaxies — not on the process of obtaining the image.

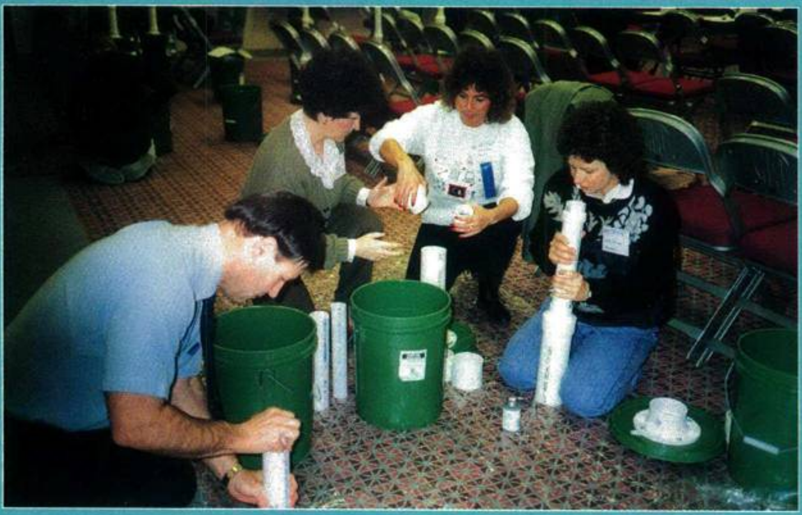
Some groups — such as the Center for Image Processing in Education in Tucson, Arizona, with its Image Processing for Teachers program — are helping teachers learn about image processing. Results from the IPT program show that image processing eliminates obstacles encountered by some students in traditional math and science teaching. At-risk students, who often have negative views of themselves and the world, frequently improve their attitudes and build self-esteem because of the appeal of the images and the opportunity to become an expert. And image processing provides a reason for students to learn about histograms, statistics, scaling, and geometry —concepts that can be boring if presented as isolated ideas in a classroom.

Many instructors have started to use computers in their lectures as well. A slide or chalk diagram of a planetary orbit is static. But computers can provide animated views of the orbit, permitting the students to stop the orbit, reverse it, and change its size. Try *that* with slides or even a film.

We Need More Scopes

Computers have certainly aided in part of the revolution in our classrooms. But one thing will always remain constant in astronomy — there's nothing like looking through a telescope. Many of us were hooked on astronomy, or science in

TEACHING THE TEACHERS


University of Toledo, SPICA

Students can't learn if properly trained teachers aren't there to share their knowledge and sense of wonder about our universe. Because few teachers take astronomy courses in college, in-service education is important. Regional teacher-enhancement programs provide the best route for this education. But few universities are doing anything about this training. One that is paving the way is the University of Toledo in Ohio.

Its UT-SPICA (Support Program for Instructional Competency in Astronomy) was modeled after the Harvard-Smithsonian Center for Astrophysics' SPICA program. It extends its workshops to elementary and middle school teachers as well as high school instructors. During each summer the UT-SPICA program trains about 25 teachers to become SPICA agents, who will give workshops about teaching astronomy to other teachers. The ripple effect is awesome. Hundreds of teachers learn from the workshops presented by agents. In turn, these teachers have exposed almost 100,000 students to the joy and wonder of astronomy.

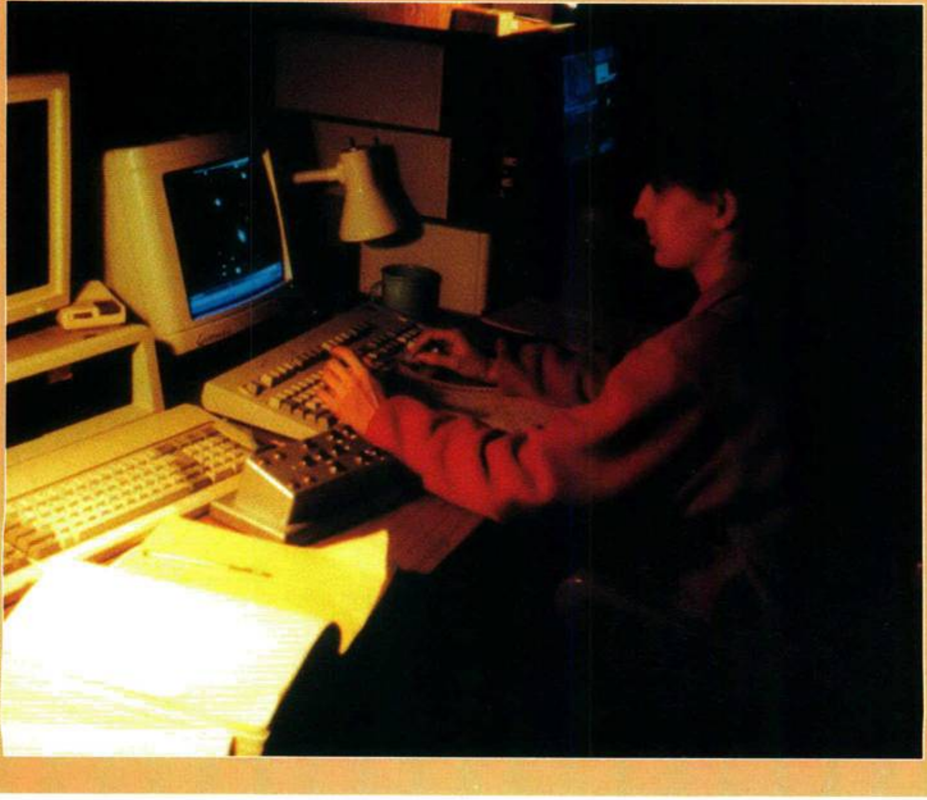
TEACHERS MAKE THEIR OWN TELESCOPES using lenses, PVC pipe, and buckets at a workshop directed by UT-SPICA agent Karen Provo (second from right).

USING COMPUTERS EFFECTIVELY

Educators have used computers in the classroom for over 20 years but never as effectively as now. Previous attempts focused on "tutorials," question-and-answer sessions with the computer acting as question poser and scorekeeper.

But such simple exercises didn't unleash the power of the computer, nor did they allow students to explore the wealth of astronomical phenomena. Astronomy programs have gone beyond the limited capabilities of early software that let you learn only star names and constellations. Nowadays, programs such as Dance of the Planets and Orbits let students explore the hows and whys of planetary motion, restrained only by the students' curiosity and sense of exploration. Optics programs let students "build" telescopes and explore what went wrong with the Hubble Space Telescope. Others probe how stars change throughout their life cycles.

Programs such as Crystal Lake Observatory's TS-24 and Gettysburg College's laboratory exercises simulate telescope observing sessions, letting students pose questions and then obtain data to test their ideas. They can measure stellar brightnesses and take spectra of galaxies. No longer is astronomy a bunch of facts because students learn to relate ideas to what they have observed. And schools that don't have telescopes or that limit nighttime activities can do "observational" astronomy through computer power.


Laurence Marschall

COMPUTERS EMPOWER STUDENTS such as Gettysburg College's Meg Grunden to process images of astronomical objects.

WHAT CAN YOU DO?

What can you do? Plenty!

Get involved with your schools. Chances are that the teachers don't know very much astronomy but would love to have you share your knowledge in the classroom or at night with a special star party. Amateurs can make a difference, even in areas that have universities and observatories.

Witness the efforts of Bob Ashford, an amateur living in San Jose, California. Bob, a Hewlett-Packard employee, volunteers his lunch time at two schools to supervise their space clubs. Bob's motto is "We just have fun!" So far they have made comets, had star parties, painted a solar system on the school grounds, and studied stars and galaxies. Schools need many other amateurs to help fill the need: Teachers are willing to help form the club, but they need your expertise and enthusiasm for astronomy.

Along these lines, the Astronomical Society of the Pacific is starting a pilot program called Project Astro to bring amateur and professional astronomers into the classroom. Initially the program will link 40 astronomers and 40 teachers throughout California. The society also is developing a "How-to" manual for the visiting astronomers and a teachers' manual. But the key word is involvement — hands-on activities, help with individual student projects, and mentoring of teachers and students.

Other avenues are also open. Some clubs, such as the Sonoma County Astronomical Society in Northern California, help students and local schools by donating telescopes that members build. But the what isn't as important as the who — your local schools need YOU.

Courtesy Robert Ashford

SPACE CLUB MEMBERS at the James B. Flood Elementary School in East Palo Alto, California, paint giant pictures of the planets in their playground with the help of amateur astronomer Bob Ashford.

general, by our first look at Saturn's rings, craters on the Moon, or the delicate belts of Jupiter.

But many schools can't afford to buy a scope, or even if they can the teachers aren't always sure what kind of telescope to buy. Some astronomy clubs have led the way by building telescopes for their local schools or by having star parties for students and their parents. Others have hosted telescope-making workshops.

Some astronomers have taken their enthusiasm for their hobby into the classroom, giving talks, showing slides of planets and galaxies, making solar system models with students acting as planets, or making "comets" from dry ice and charcoal. Others, like Bob Ashford in San Jose, California, have started space clubs. (See "What Can You Do" above.)

A few students have set out on their own, making their own telescopes. A group of students at Gross Pointe South High School in Gross Pointe Farms, Michigan, made their own radio telescope. They are starting to map the sky and study high-energy bursts from Orion. They hope to correlate any bursts with data obtained at three other radio telescopes and with gamma-ray bursts.

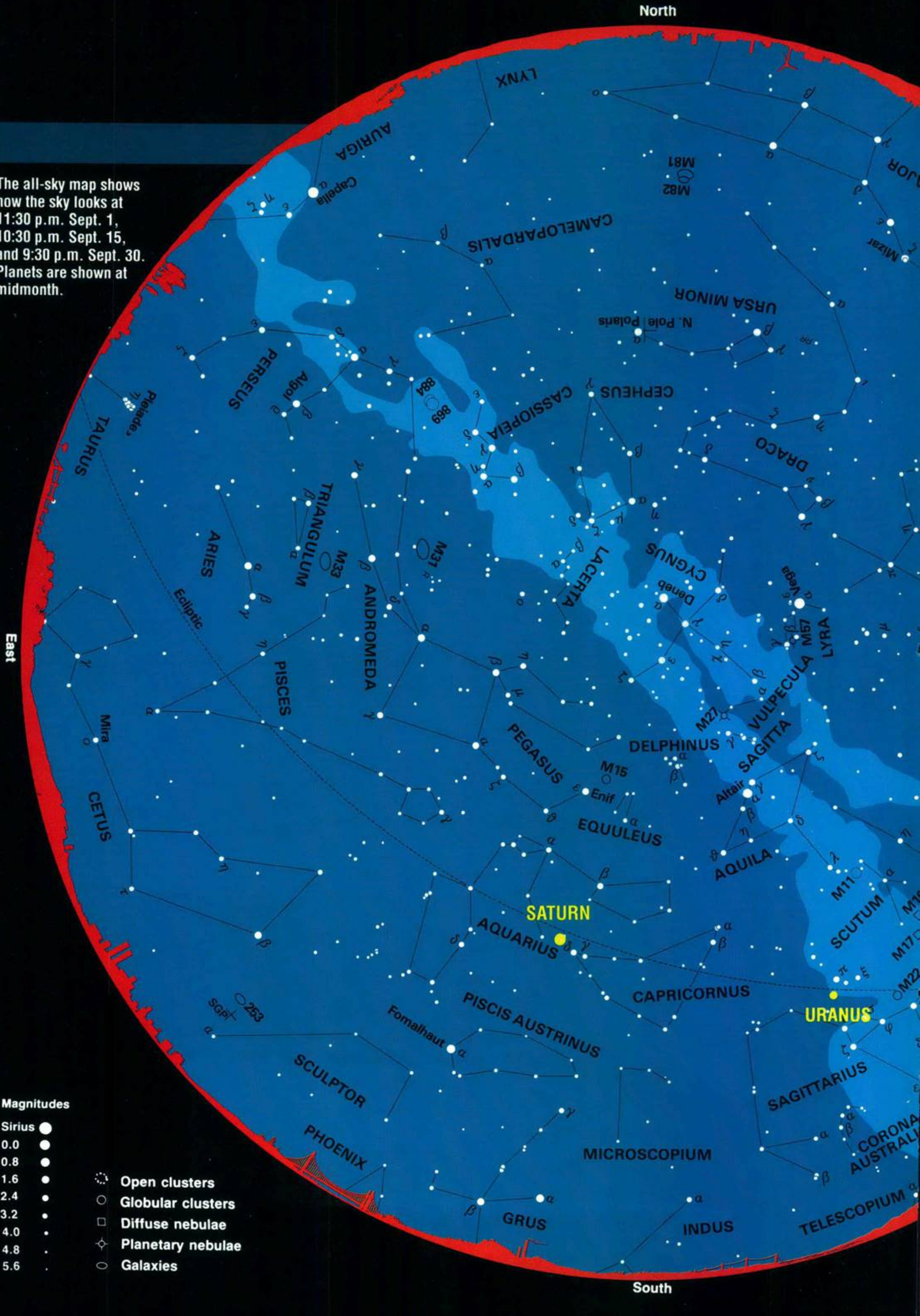
Their project taught them to believe in themselves, even when teachers doubted they could do the project. And it let them take science out of the classroom and into the real world. Katrina Koski, a student in the program, says, "It made science fun again and opened a new world of scientific thought to me."

And We Need You

Some students, like Katrina and her friends, will prosper because they already have learned how to learn. But not all students are so lucky. We can be thankful that educators like Jeff Lockwood are there in the classroom to guide and mentor students. They are breathing life into our nation's science education, which has fallen behind that of some other countries. With the innovative programs these educators are developing, our children will become science literate and thus more aware what science really is.

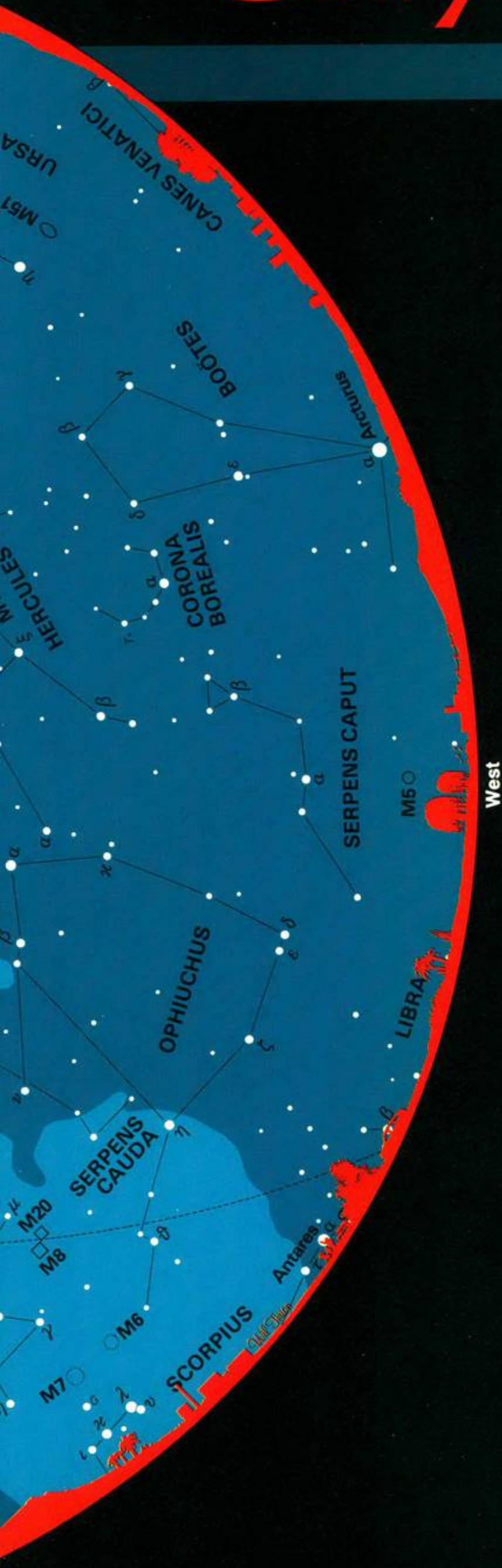
But master teachers like Jeff are few. And other well-meaning teachers don't have science or astronomy backgrounds. They need our help. Donating telescopes and computer equipment is great. So is providing schools with books, slides, and posters of astronomical objects. But they also need us to help bring astronomy to students from elementary school through college. A star party or a talk about your favorite astronomical objects can help transform students from fact-memorizers to players. Who knows? You may even hear cheers. ☐

The all-sky map shows how the sky looks at 11:30 p.m. Sept. 1, 10:30 p.m. Sept. 15, and 9:30 p.m. Sept. 30. Planets are shown at midmonth.


North
LYNX
AURIGA
Capella
M81
M82
CAMELOPARDALIS
URSA MINOR
N. Pole
Polaris
Mizar
PERSEUS
Algol
Pleiades
TAURUS
CASSIOPEIA
884
869
CEPHEUS
DRACO
TRIANGULUM
M33
M31
ARIES
ANDROMEDA
LACERTA
CYGNUS
Deneb
Vega
M57
LYRA
Ecliptic
East
PISCES
Mira
CETUS
PEGASUS
M27
VULPECULA
DELPHINUS
SAGITTA
M15
Enif
Altair
EQUULEUS
AQUILA
M11
SCUTUM
SATURN
AQUARIUS
M17
M22
CAPRICORNUS
URANUS
SGP
253
PISCIS AUSTRINUS
Fomalhaut
SCULPTOR
SAGITTARIUS
CORONA AUSTRALIS
PHOENIX
MICROSCOPIUM
GRUS
INDUS
TELESCOPIUM
South
Magnitudes
Sirius
0.0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

September 1993



MARS JOINS JUPITER

Shortly after sunset on September 6 observers with binoculars or a telescope have the chance to get a close view of a rare event. At that time Mars will be less than 1° south of Jupiter, and the two bright planets will be visible in a single low-power field of view. Look for the pair in Virgo low in the west.

VENUS MEETS REGULUS

September brings a second close encounter, this time between brilliant Venus and Leo's brightest star, Regulus. In the early morning sky of September 21, low in the east, the dazzling planet will pass just 0.4° north of Regulus, and the two objects will be a striking sight in binoculars or a telescope.

A HARVEST MOON RISING

On September 30 the Full Moon rises into the evening sky. Not just any Full Moon, however — the Harvest Moon. This moonrise, traditionally associated with harvesting autumnal crops, offers backyard astronomers the opportunity to observe lunar rays at full illumination.

SOFTLY SUBLIME SATURN

The Ringed Planet was at opposition last month, so September still offers a great opportunity to see Saturn's globe and ring system. The planet's shadow is slowly moving over the rings behind it, creating a beautiful three-dimensional quality.

Calendar of Events

3 The Moon is at apogee (252,353 miles from Earth), 1 p.m. EDT

4 Ceres is stationary, midnight EDT

6 Mars passes 0.9° south of Jupiter, 8 p.m. EDT

9 Last Quarter Moon is at 2:26 a.m. EDT

13 The Moon passes 6° south of Venus, 11 p.m. EDT

15 New Moon is at 11:10 p.m. EDT

16 The Moon is at perigee (222,082 miles from Earth), 11 a.m. EDT

21 Venus passes 0.4° north of Regulus, 2 a.m. EDT

22 First Quarter Moon is at 3:32 p.m. EDT
Autumnal equinox is at 8:22 p.m. EDT

24 The Moon passes 3° north of Neptune and 4° north of Uranus, 3 a.m. EDT

27 Uranus is stationary, 10 a.m. EDT

29 Neptune is stationary, 11 p.m. EDT

30 Full Moon is at 2:54 p.m. EDT
The Moon is at apogee (252,540 miles from Earth), 5 p.m. ET

Map Art by Wil Tirion

Eye on the Sky

by Deborah Byrd

HERE COMES AUTUMN

Earth's orbit is a 600-million-mile circuit around the Sun, a path through space that's actually invisible, no matter how many textbooks portray it as a solid line. If you can imagine Earth's orbit divided into four 90-degree sections, you can begin to get a feeling for one of this month's main events: the autumnal equinox.

The equinoxes and solstices have been celebrated for thousands of years. Nowadays, they mark the official start and end of the four seasons in the Northern and Southern hemispheres. On these days, day and night are equal in length. On the day of the equinox, September 22, you'll hear on the radio and read in newspapers that the center of the Sun crosses the celestial equator at 8:22 p.m. EDT.

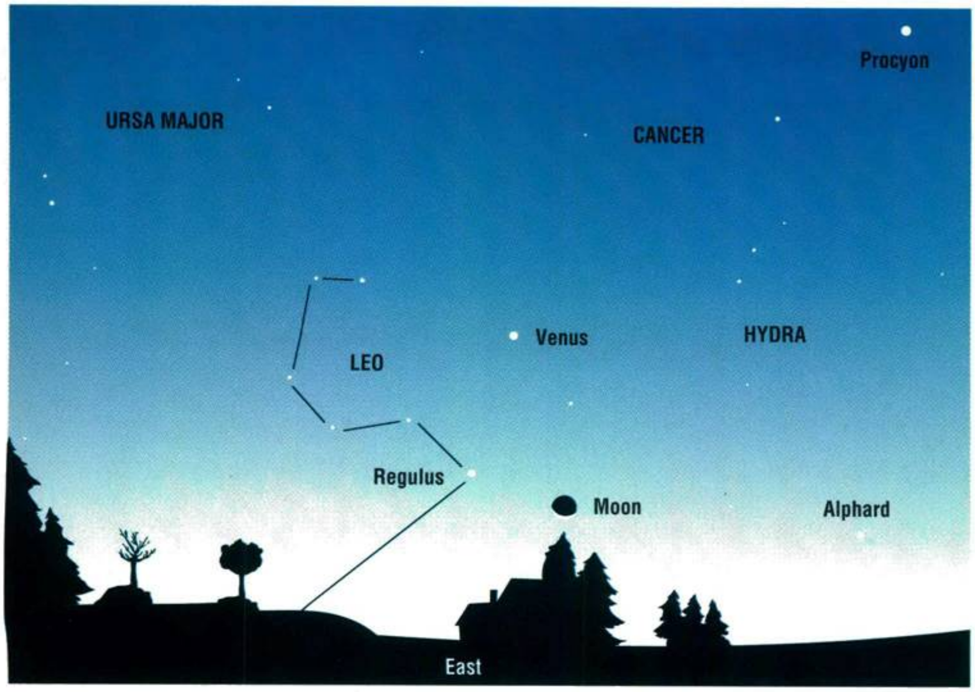
But the celestial equator is an imaginary line. What's real is our path around the Sun. The autumnal equinox is a point Earth reaches in this orbital path, and it's not even a fixed point because of precession, a motion whereby Earth's axis traces out a circle among the stars over a period of 26,000 years. The Sun at the autumnal equinox used to be located against the background of the constellation Libra. Now, if the Sun were eclipsed on the day of the equinox, you'd see it in front of the stars of Virgo.

The autumnal equinox marks the beginning of autumn in the Northern Hemisphere. On September 22, our half of the globe begins to lean increasingly farther away from the Sun. The Sun's rays strike our hemisphere at a greater angle now than three months ago, so the Sun is delivering less warmth per unit area of Northern Hemisphere ground. As a result, it's getting colder outside.

On the day of the equinox, notice that the Sun rises due east and sets due west. These points mark where the celestial equator intersects your local horizon. At sunrise on the day of the equinox, you'll see that your shadow points due west. At local noon, if you are in the Northern Hemisphere, your shadow points due north. Those standing on the equator see their shadows point straight down at noon on the day of the equinox. For them, the Sun is directly overhead.

Vincent Genna

THE HARVEST MOON illuminates the landscape once again on September 30. In the morning sky of September 14, a waning crescent Moon hangs above the horizon near Venus and Regulus (below).



SHINE ON HARVEST MOON

The Full Moon closest to the September equinox is called the Harvest Moon. According to folklore, it is bigger, brighter, and yellower than other Full Moons. This year, Harvest Moon comes on September 30.

Another illusion dashed! It's not bigger, brighter, or yellower at all. But this Moon is distinguished in other ways. There's a shorter-than-usual time between moonrises around the time of the Harvest Moon. On average, the Moon rises 50 minutes later each night. For a few days in late September and early October, you will find the Moon rising only 30 minutes later, or less, on successive evenings. And the Moon rises noticeably farther north on successive evenings around the time of the Harvest Moon.

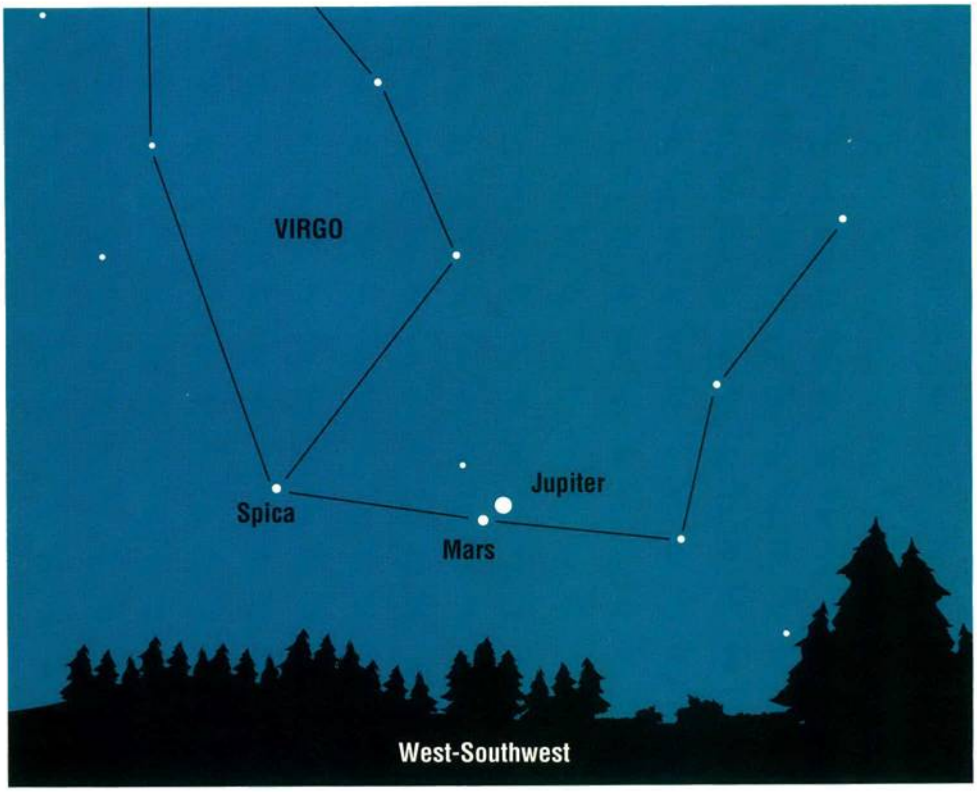
All of these effects stem from

the fact that the ecliptic — or path of the Sun, Moon, and planets — makes a narrow angle with respect to the evening horizon every autumn. If you imagine this slanted ecliptic extending below your horizon and if you realize that the Moon moves a bit farther eastward along the ecliptic each day, you might see that Earth doesn't have to turn as far now to bring the Moon into your view each day. So the time between moonrises is shorter. The overall impression is that September has more than one Full Moon.

These multiple Full Moons might help explain the folk wisdom surrounding the Harvest Moon. There are simply more chances to see a Full Moon — or what looks like a Full Moon — ascending over the eastern horizon around sunset this month. The Full Moon always looks extra big when it's near the horizon. This is a perceptual effect known as the Moon illusion. And Moons low in the sky look yellowish because then their light is shining through a greater thickness of air than when they are high in the sky, which refracts and reddens their light.

SEPTEMBER'S PLANETS

Those with an unobstructed western horizon can witness a close conjunction of **Mars** and **Jupiter** after sunset early in September. These two magnificent planets — which sometimes compete for prominence in the night sky — are now low in the western twilight. Their conjunction in right ascension takes place on the evening of September 6 in North America. The unusually close pairing should make a thrilling view in the eyepiece.



SEE MARS AND JUPITER pass within 0.9° of each other in the evening sky on September 6. Binoculars will show the planets in a single field of view.

On that evening Mars and Jupiter appear about 55' apart on the sky's dome. They are slightly closer — only about 50' apart — on the evening of September 5 in North America. The low angle of the ecliptic does not help their visibility, so be sure to look no later than about 45 minutes after sunset. Jupiter shines at magnitude –1.7. Mars is much fainter at magnitude 1.6. Binoculars will help you follow the planets nearly to the horizon.

To the left of Mars and Jupiter is the star Spica in the constellation Virgo. The three form a line early in the month. Then Mars breaks away from Jupiter and passes 2 1/2° north of the star on September 16. The Moon returns to this part of the sky around September 18.

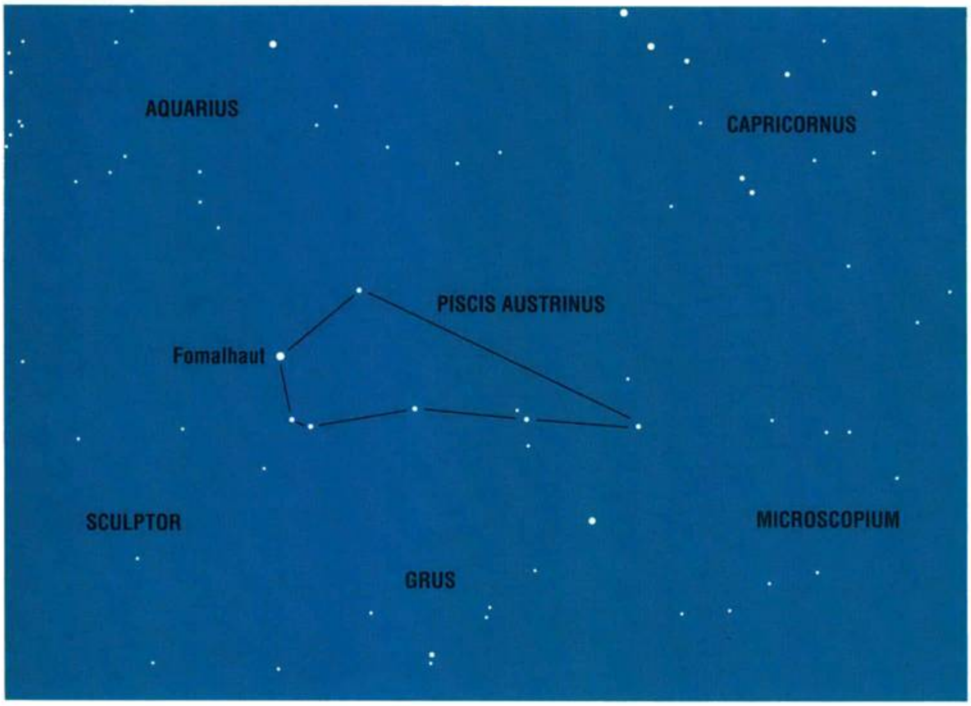
Before the month ends, **Mercury** joins the planets in the western twilight sky. It is 2° south of Jupiter on September 24 and 1° south of Spica on September 26. The planet is bright at zero magnitude, but seeing it will be difficult. Again, the low angle of the ecliptic on these autumn evenings hinders the view.

Saturn is now up in the southeast at sunset. This golden planet ornaments the sky nearly all night. Only a month past its opposition, it's still nearly at its brightest for the year at magnitude 0.4. Saturn is on the western edge of Aquarius, not far from the arrowhead asterism of the constellation Capricornus the Sea Goat. The 3rd-magnitude star near the planet is Deneb Algedi, the brightest star in Capricornus, a white subgiant whose name identifies it as the Sea Goat's tail. Watch the planet edge closer to the star throughout September. They start out a little over 2° apart and end up slightly more than a degree apart. Also look for the Moon near Saturn on the evening of September 26.

Night passes with no new planets rising over the eastern horizon until **Venus** comes up shortly before the Sun. The brightest planet can be found low in the east at dawn. It begins the month nearly in front of Praesepe, also known as the Beehive star cluster, in the constellation Cancer. Binoculars will afford some interesting views of Venus and the Beehive before dawn washes the sky.

By September 13, you'll see that Venus has shifted below the Beehive in the east. On that morning, the waning crescent Moon appears near the planet. The next day, the Moon has sunk closer to another bright object emerging from the dawn. This is the star Regulus, the heart of the lion in the constellation Leo. Venus and Regulus have a close conjunction on September 21. Then they are only about one quarter degree apart.

PISCIS AUSTRINUS, the Southern Fish, is a relatively obscure Southern Hemisphere constellation best known for its lone bright star, Fomalhaut.



THE STARRY SKY

This month, as you are watching Saturn sweep across the southern sky each evening, shift your gaze lower in the south to find the constellation Piscis Austrinus, the Southern Fish.

This constellation is located to the southeast of Capricornus and directly south of Aquarius. It is low in the sky as seen from the northern United States and Canada, but it will be well placed for viewing in the next few months. It consists of mostly 4th-magnitude stars.

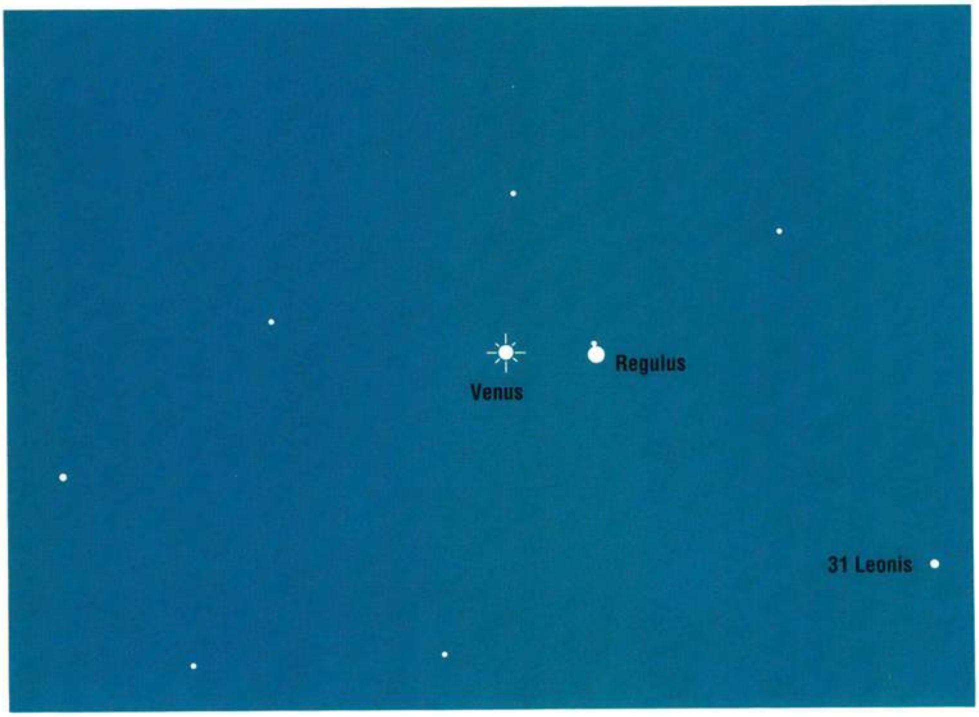
Piscis Austrinus is one of many constellations in this region of the heavens associated with water. These constellations include Aquarius the Water Carrier, Capricornus the Sea Goat, and Cetus the Whale. The Southern Fish is often pictured in old star atlases with its mouth wide open. Water from the Water Jar asterism of Aquarius is shown streaming into the mouth of the Fish. This is interesting, since fish don't drink water! In the sky, you will see a zigzag line of stars from the Water Jar in Aquarius to Piscis Austrinus.

The brightest star in Piscis Austrinus is Fomalhaut. Its name comes from the Arabic *Fum al Hut*, meaning "the fish's mouth." This star shines at magnitude 1.2 in an otherwise empty region of the sky. Fomalhaut has Saturn for company this year, but in many years it deserves its reputation as "the loneliest star." ☐

Deborah Byrd writes and produces the daily "Earth and Sky" radio series and is a regular contributor to Astronomy.

by Jeff Kanipe

VENUS AND REGULUS COME TOGETHER



A TELESCOPIC TREAT awaits you on September 21, when brilliant Venus passes within just 18' of Leo's brightest star, Regulus. Venus will display its gibbous appearance (below) this month.

Gary Holland

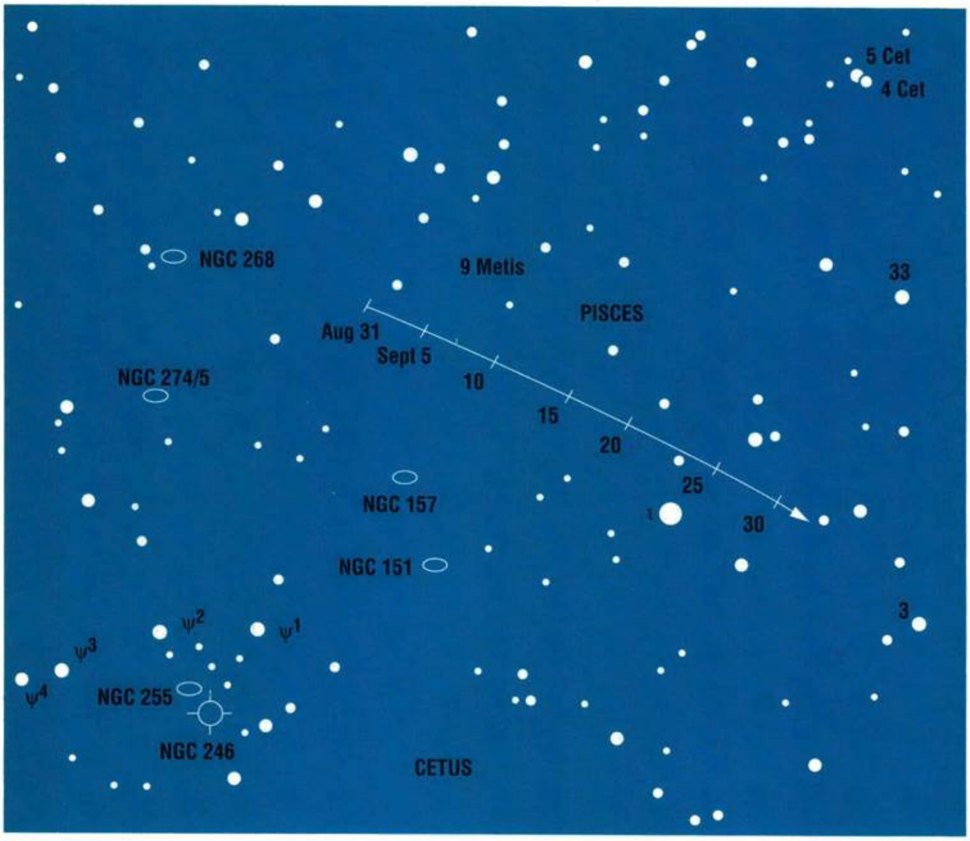
It may now be September outside your window, but autumn is definitely around the corner. For those at northerly latitudes anyway, especially in the northeast, there already may be a decided nip in the air, and it's only a matter of time before the smell of burning leaves and the first chimney fires scent the air.

With the onset of autumn come those wonderful high-pressure weather systems that calm the atmosphere as well as the spirit. Usually a cool front moves through, followed by days of blissfully clear, dry skies, calm winds, and steady temperatures. The optimum time to observe while such conditions exist is during the early morning hours, when the air temperature has steadied down and dust and other particulates have had a chance to settle out of the atmosphere. This leaves you with a pellucid, stable sky, with maybe just a little dew to contend with. These factors combine to form those rare, nearly perfect observing nights.

Maybe you'll encounter such conditions the morning of September 21, when Venus edges near the blue-white star Regulus in the eastern predawn sky. With moderate magnification, Venus presents a nearly full disk (gibbous early in the month), but its diameter (12") is about one-quarter what it was in late April, when the planet had just emerged from inferior conjunction in the morning sky. At that time the planet's disk was a striking crescent with the horns nearly extending around the globe (as it also appeared in mid-March in the evening sky). Venus is also moving toward the back side of the Sun, so its distance is ever increasing. Still, Venus is a brilliant object at magnitude – 4.0, a testimonial to the reflective power of clouds.

On the morning of the 21st, Venus lies only 18' north of Regulus. Given the angular separation between these two objects, you should be able to zoom in tightly and yet still keep them in the same field of view. An eyepiece with a quarter-degree true field of view should be able to contain them both. The contrast between these two objects will be their most striking aspect. At magnitude 1.3, Regulus virtually pales in comparison to the great "morning star." But of course this B-type dwarf star is 69 light-years away.

While you're observing this planet-star pair, take a close look at Regulus, which is a visual multiple star system. Regulus' 8th-magnitude yellow (some say orange) companion lies 177" northwest and is an easy target in a small telescope. More difficult is the companion's companion. With a separation of less than 3" and a magnitude of about 13, this isn't an easy find. I recommend an 8-inch telescope and steady skies. If you are blessed with the former, and the weather is as cooperative as it often is this time of year, you should be able to spot this challenging object.Find the star at low power and then increase your magnification to 100x. That should give you a good view of the two brightest stars. To see the secondary's companion, center on that star



THE ASTEROID 9 METIS moves slowly through Cetus this month. Its 9th-magnitude glow can be seen in the same low-power field as Iota (ι) Ceti near month's end. Several bright galaxies lie nearby, including NGC 151 and NGC 157.

COORDINATES FOR 9 METIS

Date	R. A. (2000) Dec.
Aug. 31	0h37.0m −5°54'
Sept. 05	0h34.1m −6°20'
Sept. 10	0h30.6m −6°48'
Sept. 15	0h26.6m −7°17'
Sept. 20	0h22.2m −7°45'
Sept. 25	0h17.5m −8°11'
Sept. 30	0h12.7m −8°34'

and increase the power to 200x if the seeing permits.

SATURN: JUST PAST OPPOSITION

Less than a month after opposition, Saturn is still well placed in the southeast just after sunset. Although opposition is the best time for viewing a planet, the very day of opposition may not be as interesting as the weeks preceding and following opposition. I think this is true for all the outer planets, but particularly for Saturn.

No other planet looks as three-dimensional in the telescope as Saturn. The image of a disk inserted within a ring that goes behind the disk sends a clear, unambiguous signal to the brain: "You are not looking at a mere planar object. You are looking at a real world." This may be why Saturn has such a profound effect on people when they see a clear, sharp view of the planet for the first time in a telescope. Abruptly they must confront the idea that a real universe exists apart from their own world, one with physical dimensions. In a sense, the naive observer experiences the same powerful feelings that prompted the Catholic Church in the 1600s to censor Galileo — except that, for most of us, the feelings bring pleasant consequences!

Saturn's shadow adds dramatically to its three-dimensional quality. Before opposition, the shadow is visible as a wedge-shaped void at the point where the eastern limb intersects the rear portion of the rings. After opposition, it emerges from the western or preceding limb. Around opposition, however, the shadow isn't visible because we're looking at Saturn fully lit from the front, and the shadow is cast directly back from the planet where we cannot see the rings.

Now that we're past opposition, though, the coming weeks will be a good time to begin watching the shadow as it gradually becomes more prominent. (The shadow is best seen around quadrature, which occurs this year on November 16.) Look also for the narrow shadow of the rings cast along the equatorial region of Saturn. Almost any telescope will show the shadow, though a good instrument might be an 80mm at, say, 40x. A refractor in the 4-inch class at magnifications between 90x and 120x provides perhaps the best high-contrast views, although the planet's appearance through a well-collimated 8- or 10-inch Schmidt-Cassegrain or Newtonian reflector will be very satisfying.

URANUS AND NEPTUNE TEAM UP

Uranus and Neptune, which have been hovering near each other all year, are separated by only 1.1° on the evening of September 28. (The difference in angular distance varies only about a tenth of an arcminute for the entire month, so you won't see much, if any, difference throughout September.) This is a great opportunity to observe both of these remote planets in a single telescopic field of view. And for those of us observing today, it's a once-in-a-lifetime event. An eyepiece with a true field of view of 1.25° will comfortably encompass the pair.

The planets are situated in Sagittarius, which is where they've both been for the past seven years (Neptune, even longer). In late September, they lie about 2° southeast of Pi Sagittarii. Uranus, in fact, forms the southernmost point of a right triangle composed of Pi and 4th-magnitude Rho Sagittarii.

Neptune lies just "above" (northeast of) brighter Uranus, which means it will be "below" Uranus in an inverted telescopic field of view. Glowing at 8th magnitude, Neptune is not going to leap out at you in the eyepiece, but its color, a distinct aqua blue, should alert you to its presence. The altitude of these planets and, hopefully, a settled atmosphere should allow you to boost magnifications as high as 30x or 40x per inch of telescopic aperture. You'll need that much to see anything of Neptune's disk. Less than that and the planet appears as little more than a dot (although even at higher power, it's merely a bigger dot).

Uranus, on the other hand, is quite bright (magnitude 5.7), and with an apparent diameter of nearly 4", its disk is fairly obvious in any telescope at moderate to high magnifications. With a low-power, wide-field eyepiece, you should have no trouble spotting Uranus' greenish hue.

ASTEROIDS IN THE EYEPIECE

Rising just after sunset, the dim constellation Cetus is the hunting ground for the asteroid **9 Metis**, which comes to opposition on the 23rd. This 111-mile-diameter minor planet spends all this month and part of the next slowly moving through southwestern Cetus. It passes north of the bright star Iota Ceti around September 25.

Early in the month 9 Metis moves about a degree every day and a half. The pace slows gradually thereafter, and by mid-September Metis takes about three days to move one degree.

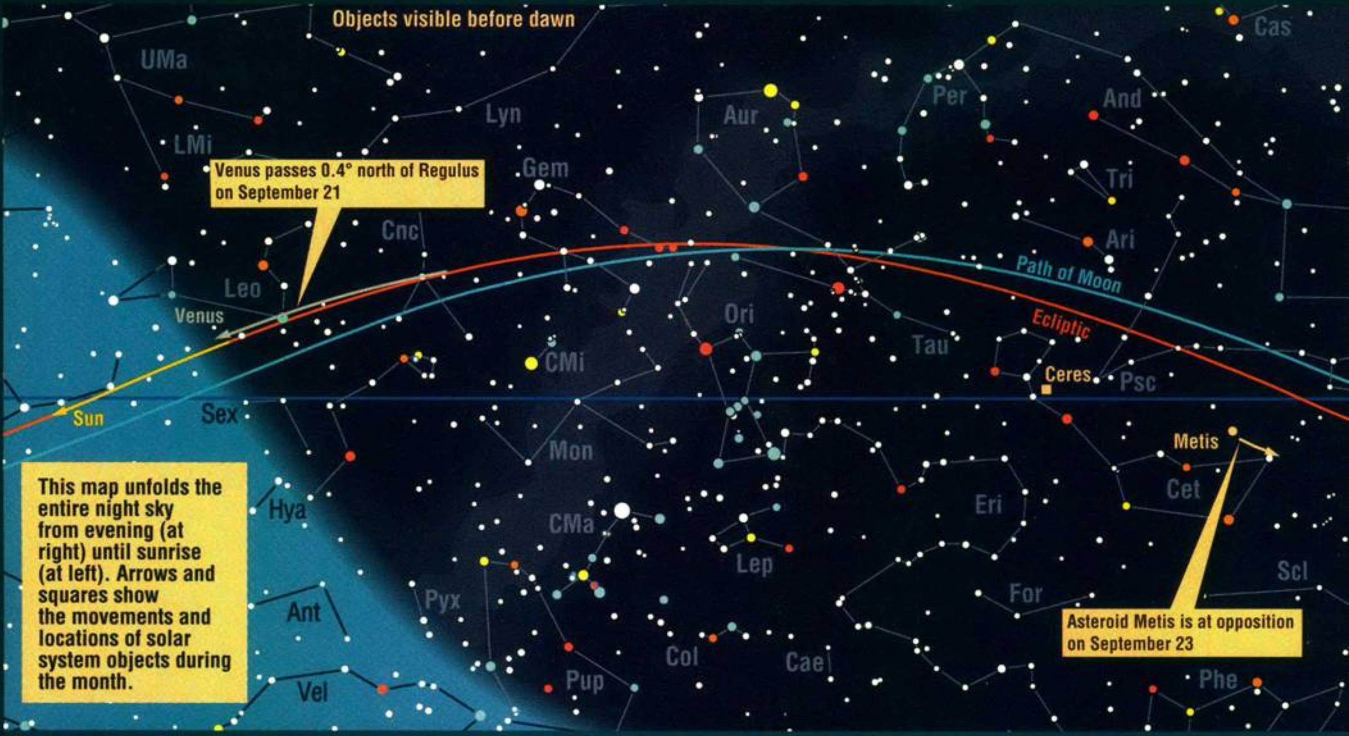
At opposition, 9 Metis glows at magnitude 9, bright enough to be seen in a 3-inch telescope. See the finder chart opposite to locate the asteroid. Be sure to start off using a low-power eyepiece (a 32mm to 25mm eyepiece will do) so you can search out your field. Once you have the asteroid located, zoom in with a 16mm to 12mm eyepiece and sketch the center of the field, being careful to note your sky directions on the chart. Come back the next favorable evening and compare your sketch with the new field of view. One of the "stars" in the field should have moved. Can you find its new location? Look around for a star that shouldn't be there. That is 9 Metis. □

Dan Schecter

THE RINGED PLANET is well-placed for viewing after sunset. Moments of good seeing provide a sharp, three-dimensional view of the planet. The photo shows Saturn in 1990; its north pole now tips toward us.

Jeff Kanipe is the editor of Star Date *magazine, which is published by McDonald Observatory at the University of Texas at Austin. He also writes an astronomy column for the Associated Press.*

The Solar System   September 1993


Objects visible before dawn
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Leo
Venus
Sun
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Tau
Path of Moon
Ecliptic
Ceres
Psc
Metis
Cet
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Cae
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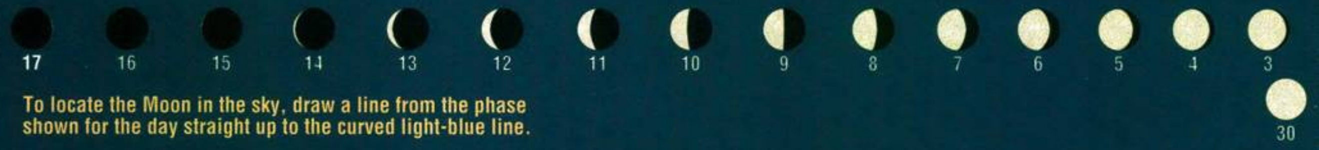
Venus passes 0.4° north of Regulus on September 21

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

Asteroid Metis is at opposition on September 23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To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

10"

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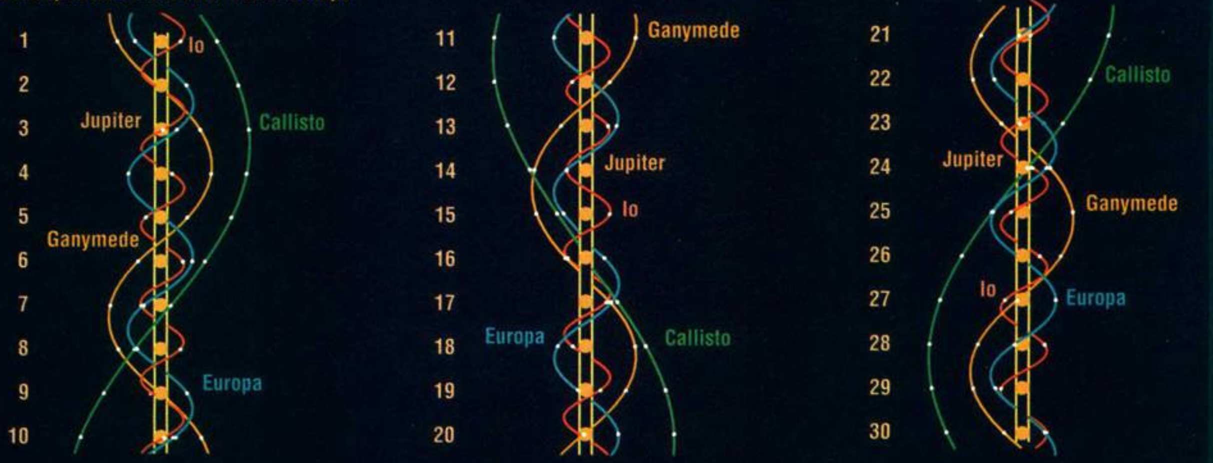
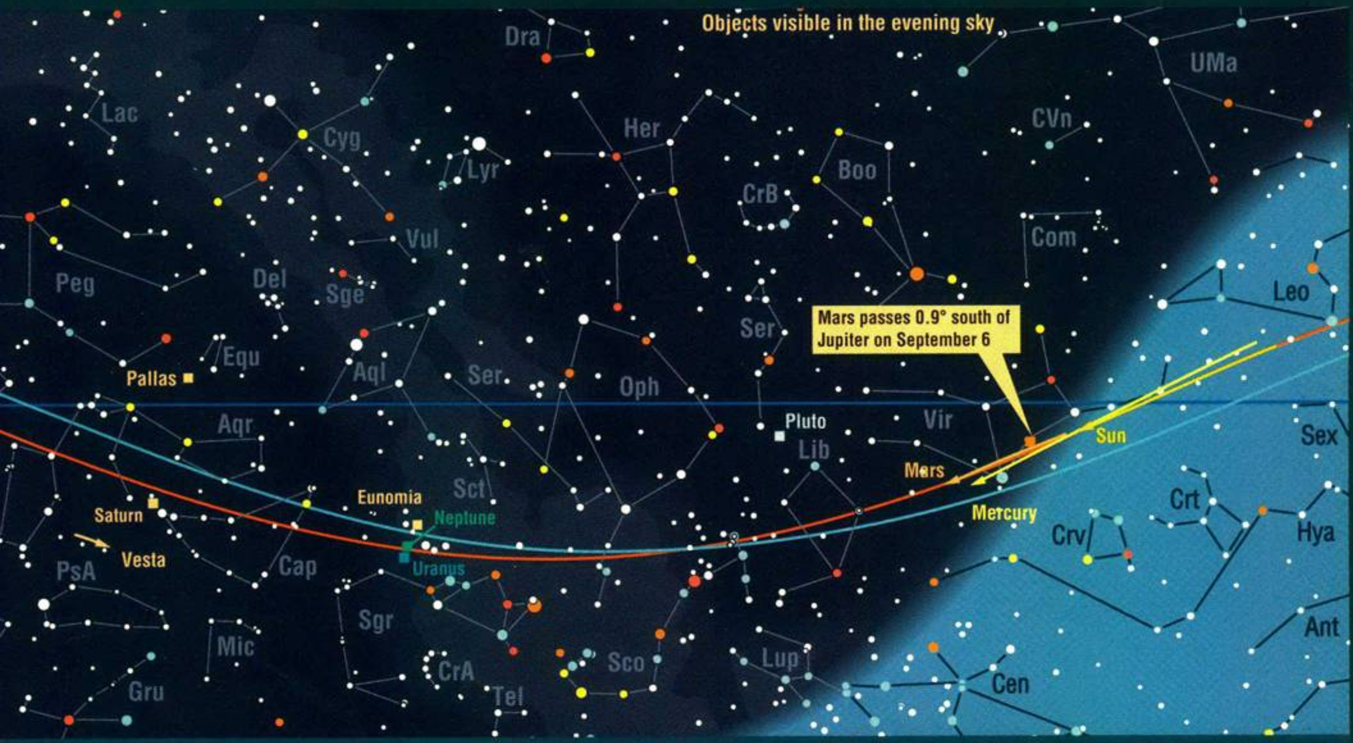
PLANETS	MERCURY	MERCURY	VENUS	MARS
Date	September 15	September 30	September 15	September 15
Magnitude	–0.5	–0.1	–4.0	1.6
Angular Size	5.0"	5.5"	12.1"	4.0"
Illumination	92%	80%	86%	97%
Distance (AU) from Earth	1.348	1.214	1.381	2.366
Distance (AU) from Sun	0.441	0.466	0.719	1.574
Right Ascension (2000.0)	12h22.6m	13h44.2m	9h38.6m	13h21.7m
Declination (2000.0)	–2°01'	–12°21'	14°45'	–8°23'

Jupiter's Moons

Dots display positions of Galilean satellites at 11 pm EDT on date shown. South is at top to match the view in a telescope.





Objects visible in the evening sky

Mars passes 0.9° south of Jupiter on September 6

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Pluto
Vir
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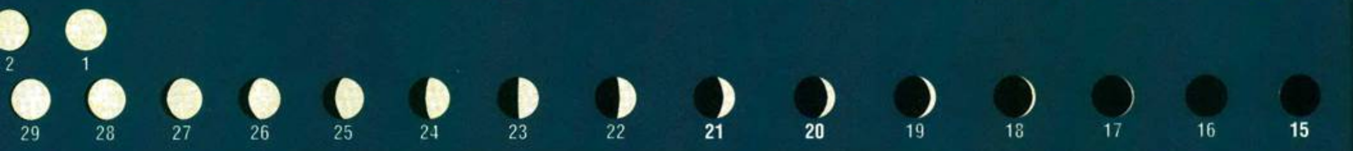

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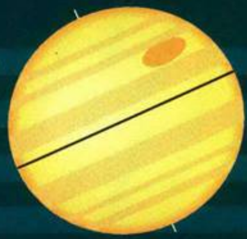
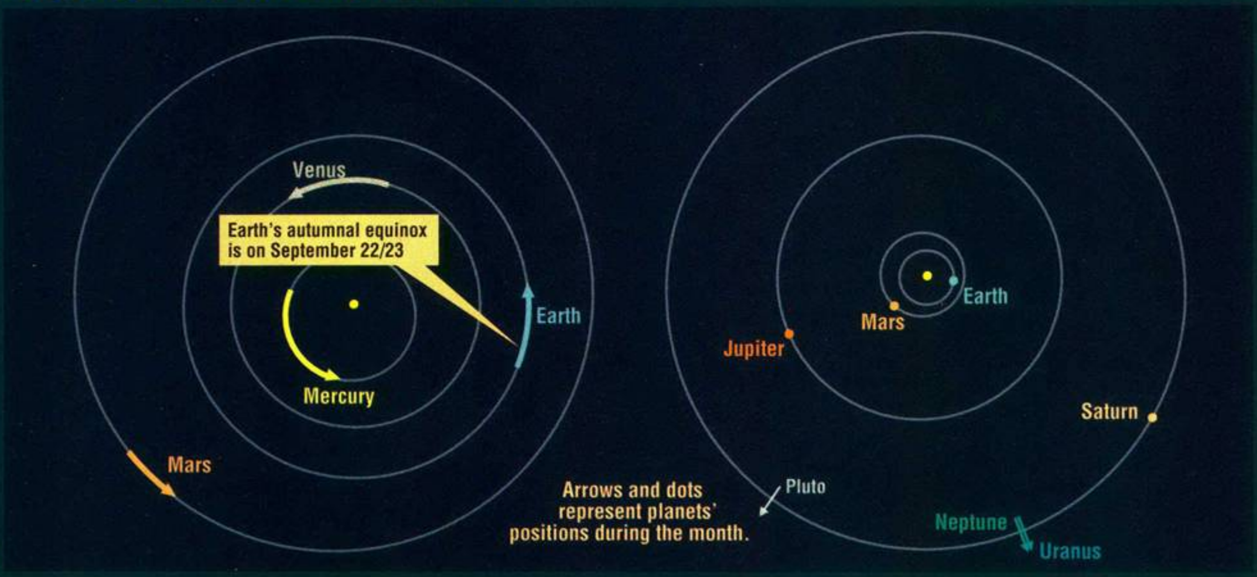


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
September 15	September 15	September 15	September 15	September 15
–1.7	0.4	5.7	7.9	13.8
31.1"	18.6"	3.7"	2.3"	0.1"
100%	100%	100%	100%	100%
6.340	8.899	19.152	29.725	30.207
5.452	9.805	19.615	30.183	29.748
13h08.1m	21h52.0m	19h19.9m	19h19.8m	15h37.7m
–6°03'	–14°35'	–22°39'	–21°30'	–5°02'

The Planets in Their Orbits



Earth's autumnal equinox is on September 22/23

Arrows and dots represent planets' positions during the month.

Venus
Earth
Mercury
Mars
Earth
Mars
Jupiter
Saturn
Pluto
Neptune
Uranus

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**Plossl test, "SKY & TELESCOPE," p490-492, May 1988*

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8'' LX200 Schmidt-Cassegrain with computer (add $105 P&S)	**$2295**
Wedge for photographing with 8'' LX200	**$110**
10'' LX100 Schmidt-Cassegrain w/super wedge (add $145 P&S)	**$2695**
10'' LX200 Schmidt-Cassegrain with computer (add $145 P&S)	**$2595**
Super Wedge for photography with 10'' LX200	**$395**
8,000 Object CNGC Library	**$99**

OTHER SCHMIDT-CASSEGRAINS

NEW! **SSC-8**, 8'' Schmidt-Cass on LXD-600 mount (add $105 P&S)	**$1795**
NEW! **SSC-10**, 10'' Schmidt-Cass on LXD-600 mount (add $145 P&S)	**$2095**
NEW! **SSC-12**, 12'' Schmidt Cass on LXD-700 mount (add $195 P&S)	**$3850**
NEW! **SSC-14**, 14'' Schmidt-Cass on LXD-700 mount	***Avail. Summer '94***
Meade 2045D 4'' f/10 with motor drive (add $40 P&S)	**$699**
Meade 2080B 8'' f/10 with tripod, wedge, MCOG (add $85 P&S)	**$1149**
NEW! Model 2120B 10'' f/10 w/wedge, tripod, MCOG (add $125)	**$1449**

PHOTOGRAPHY ACCESSORIES

LUMICON Cassegrain EASY-GUIDER f/6 or f/10	**$225**
LUMICON Giant EASY-GUIDER for 10'' f/5-f/10 operation	**$395**

MEADE STARFINDERS

8'' f/6 $699*

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions and technical specifications for 6'' to 16'' Starfinders. These are complete telescope systems with motor drive, mount, finderscope and 25mm (=48X) eyepiece.

6'' f/8 Starfinder 6(add $50 P&S)	**$599**
8'' f/6 Starfinder 8 (add $60 P&S)	**$699**
10'' f/4.5 Starfinder 10 (add $75 P&S)	**$799**
16'' f/4.5 Starfinder 16 (ship. freight COD)	**$2195**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated shipping charge to the price. LUMICON showroom prices are $96 higher.

ACCESSORIES

LUMICON carries the full line of Meade accessories. See the Meade ad in this magazine for detailed prices and descriptions.

Meade #43 Single axis drive corrector	**$99**
LUMICON DX200 Dual-axis drive cor.	**$249**
Meade 47M Dual-axis drive corrector	**$450**
LUMICON DX2BP Dual-axis drive corrector with built-in battery pack	**$299**

LUMICON® SKY VECTOR™

Higher Performance — Lower Price

LUMICON ACCESSORIES

LUMICON, 2111 Research Dr., #5, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $399

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $499

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

NGC SKY VECTOR™ $699

IMPROVED!—5500 Additions / Corrections

NGC-Sky Vector™
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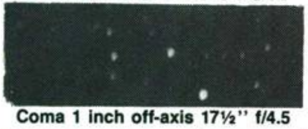
MODE
ENTER
UP
DOWN
LUMICON®

Improved NGC SKY VECTOR with over 12,000 object memory including the planets, complete, corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR



Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER	**$169.50**
2'' EASY-GUIDER (Mamiya 645)	**$199.50**
2'' Adapter for Pentax 6x7	**$129.00**
2'' Adapter for Hasselblad	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$235.00**

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	**$119.50**
UV/Dust Deal for Celestron C-8	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14	**$89.50**

NEW! LOW PROFILE HELICAL FOCUSERS

FROM $59.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$59.50**
LUMICON 2'' Helical Focuser 1½'' high	**$65.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' **adapter** w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$59.50**, right-angle	**$59.50**
1¼'' straight-thru 80mm SUPER-FINDER	**$169**
1¼'' right-angle 80mm SUPER-FINDER	**$179.50**
1¼'' right-angle version, w/star diagonal	**$209**
25mm Cross-hair 1¼'' eyepiece (12X)	**$39**
Large mounting rings for 80mm Finder	**$55**
1¼'' Star Diagonal **$39**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$52.44**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc.	**$26.00**
2'' adapter for C-80, C-100 refractor	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension	**12.00**
2½'' long extension (holds 1¼'' filters)	**16.00**
4½'' long extension for 1¼'' eyepieces	**$25.00**
3'' long extension for 2'' eyepieces*	**$26.00**
2'' long extension for 2'' eyepieces*	**$26.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$20.00**
2''/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices.

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

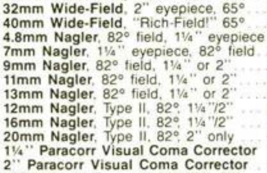
M-16, The Eagle Nebula, in Serpens. 45 minute photo by Tony Hallas and Daphne Mount using a 14" SCT and a LUMICON Giant Easy-Guider at f/7.5 with hypered TP 2415 film. "**If it wasn't for your accessories, these astrophotos wouldn't be possible,**" said Tony. M-16 is seen best with a LUMICON UHC Filter, and photographed best in color with a LUMICON Deep-Sky Filter.

"I'd Pick The TELE VUE™"

40mm Wide-Field Test, "Astronomy," Aug. 1990, p. 90

Genesis 4" f/5 4 element fluorite	$1595
Pronto 70mm f/6.4 apochromat w/2" diagonal	$798
Pronto 70mm f/6.4 w/45° erecting prism	$698
Complete Equatorial Mount	$795
Motor Drive for above mount	$239
7.4, 10.4, 13, 17, 21, 26mm Plossl 50°	$79
1.8x or 2.5x Tele Vue Barlow Lens	$89
2" Giant Barlow - 2x	$189
32mm Plossl, widest true field in 1¼"	$109
55mm 2" Plossl, widest possible field	$219
15mm Wide-Field, 1¼" eyepiece, 65°	$135
19mm Wide-Field, 1¼" eyepiece, 65°	$145
24mm Wide-Field, "Rich-Field!" 65°	$169
32mm Wide-Field, 2" eyepiece, 65°	$239
40mm Wide-Field, "Rich-Field!" 65°	$299
4.8mm Nagler, 82° field, 1¼" eyepiece	$149
7mm Nagler, 1¼" eyepiece, 82° field	$189
9mm Nagler, 82° field, 1¼" or 2"	$219
11mm Nagler, 82° field, 1¼" or 2"	$235
13mm Nagler, 82° field, 1¼" or 2"	$249
12mm Nagler, Type II, 82°, 1¼"/2"	$249
16mm Nagler, Type II, 82°, 1¼"/2"	$289
20mm Nagler, Type II, 82°, 2" only	$340
1¼" Paracorr Visual Coma Corrector	$159
2" Paracorr Visual Coma Corrector	$249
NEW! 22mm Panoptic 1¼"/2", 68°	$249
NEW! 35mm Panoptic 2", 68° field	$325

ADJUSTABLE PIGGYBACK MOUNT



The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$49.00	$39.00
52, 55, 58, 62mm	$59.00	$49.00
67, 72, 77mm	$69.00	$59.00
82mm	$79.00	N/A

Hypered 2415 film, 36 exp ... $10.95, $3/$29

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	$99.50
2" (1.83" mirror)(see photo above)	$159.00

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY February 1991

AMAZING OIII FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90-96% for both O-III lines at 496nm and 501nm.

SEE THE HORSEHEAD!

Horsehead Nebula in Orion. This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."*
Astronomy, Feb. 1991

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	$59.50
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	$79.50
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	$119.50
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$119.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	$299.50
2" Rear Cell Filter, fits SCT's ... Deep-Sky, **$119.50** UHC, O-III, H-Beta,	$199.50
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	$199.50
Set of both premium **DEEP-SKY** and **UHC Filters** (Save 11%) ... 1¼" **$159.50**; 48mm	$279.50
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** ... **$99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines ... 1¼" **$99.50, 48mm**	$199.50
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	$6.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$16.00
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$20.00

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.
U.S. Patent 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$169.50**
3X Relay Diagonal (see photo)	**$89.50**
Illuminated reticle eyepiece system	**$99.50**

Guider for Hasselblad **$350,** Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$225.00**
Adapter for Hasselblad **$198,** Mamiya 645 **$98**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ...... **add $99.95**
Adapter for Hasselblad **$229,** Mamiya 645**$129**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures ... **$9.95**

3. **LUMICON Digital Drive Corrector** . **$249**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 30Hz/90Hz variable output controls telescope drive. 60Hz digital reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Dec. reverse switch for Newtonians.

Declination motor (state telescope) ... **$109**
Variable dec. speed drive w/built-in 5AH battery **$299**

HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.) ***No C.O.D.s.***

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	**$10.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Ektar 1000 fast, fine grain	24	**$12.95**
Fuji HG400 fine grain color neg.	12	**$10.95**
3M 1000, fastest slide film	12	**$12.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

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MOON OBSERVER'S NOTEBOOK

PTOLEMAEUS & THE STRAIGHT WALL

Explore two prominent craters and a lunar cliff from your backyard.

by Michael T. Kitt

First Quarter is a splendid time for lunar observing. The lunar terminator, the boundary where night meets day, crawls across the heavily cratered highlands near the center of the Moon's disk, illuminating craters in ragged relief. Two such craters are Ptolemaeus and Alphonsus, walled plains that dominate the south-central area of the Moon's disk. A walled plain is a crater whose floor is flooded with lava. Ptolemaeus and Alphonsus are visible on the eastern edge of Mare Nubium, one of the dark "seas" that forms the Moon's basic naked-eye appearance. The walled plains are prominently visible in any small telescope and so are several unusual features near these great scars on the lunar surface.

On the next clear night when the Moon is near First Quarter, aim your scope at the Moon. Crank up the magnification to moderate (150x or so) and center **Ptolemaeus**, which measures 150 kilometers across. The feature you're now looking at, the result of a huge impact, has experienced a traumatic existence. Long ago its rim was bombarded by infalling meteoroids. Later its floor filled with lava.

Ptolemaeus offers a grand opportunity for observing. If you view this formation when the lunar terminator has moved far enough west to illuminate its eastern rim but the Sun is not yet high enough to throw rays onto the plain's floor, you can witness a treat — sunrise on Ptolemaeus.

Initially you'll see the first rays of sunlight on the western end of Ptolemaeus' floor. When sunlight strikes the floor of Ptolemaeus at such an extreme grazing angle, you can see an amazing variety of low-relief features, including tiny craters, hills, and uneven depressions.

The smaller and younger walled plain **Alphonsus**, some 120 km across, stands immediately south of Ptolemaeus. The northern end of Alphonsus overlays part of the rim of Ptolemaeus. The walls of Alphonsus are higher and better preserved than those of its northern neighbor, and it shows a distinct central peak. A medium aperture scope reveals two fine rilles on the eastern side of Alphonsus' floor.

The most distinctive feature of Alphonsus can be seen with the smallest scopes and is best observed after the Sun rises high over this formation: three dark spots on the floor of the crater. These spots are volcanic vents that have spewed dark material into surrounding rings.

West of Alphonsus, on the floor of Mare Nubium itself, is the 35-km-diameter crater **Davy**. On the northern edge of Davy you'll see the crater's giant companion, the ancient flooded remnant **Davy Y**, more than twice Davy's size. Davy Y's floor contains a straight line of craterlets.

The fresh crater **Arzachel** stands south of Alphonsis. Its features are well preserved over its 100-km diameter. It has a tall rim, a highly developed system of slumped terraces along its inner wall, and a large central peak. A single rille, much wider than the ones in Alphonsus, snakes its way along the eastern edge of the crater floor. Nestled between the western edges of Arzachel and Alphonsus is the smaller crater **Alpetragius**. Its prominent central peak almost fills this crater.

One day after First Quarter Moon, sunlight spreads over one of the Moon's most remarkable features. **Rupes Recta**, better known as the Straight Wall, lies near the eastern edge of Mare Nubium just southwest of Arzachel. The grazing light of sunrise reveals that the Straight Wall nearly bisects an ancient "ghost crater," an unnamed crater almost completely covered by lava.

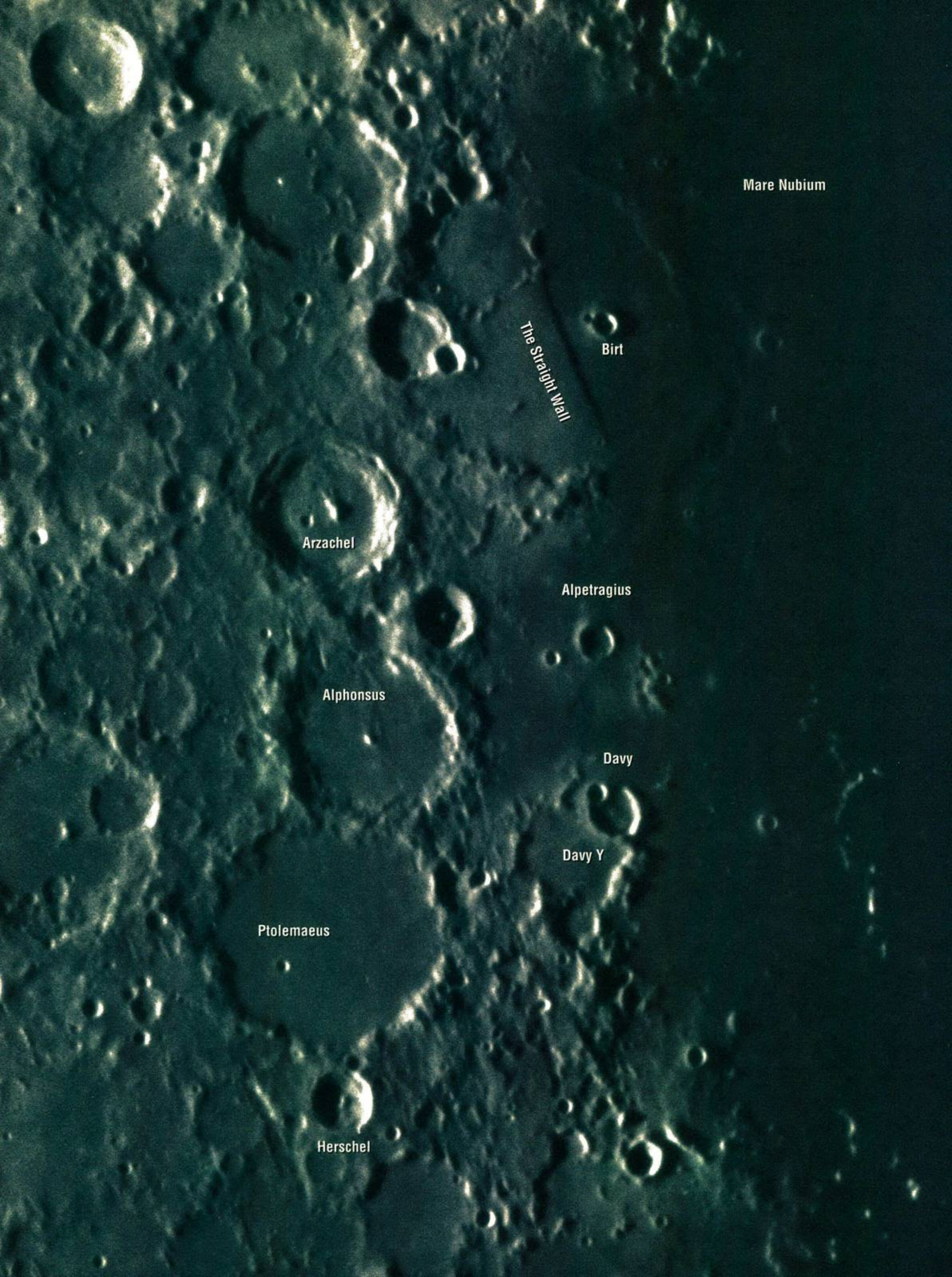
CRATERS, FRACTURES, AND RILLES speckle the eastern shore of Mare Nubium. The region's most prominent features are the craters Ptolemaeus and Alphonsus, and the Straight Wall. In the photo opposite, south is at top to match the view in a telescope.

As sunrise occurs over the Straight Wall, you'll see a wide black shadow cast onto the smooth lava to the west. This tells you that the eastern side of the formation is higher than the western side. At first the shadow is so wide it is visible with any telescope. But as the Sun rises higher, the shadow narrows until it all but disappears from view a few days before Full Moon. But the Straight Wall reappears a few days before Last Quarter Moon as a thin bright line. This bright line is the result of the setting Sun's rays striking the sloped face of the wall more directly.

The Ptolemaeus-Straight Wall region is a terrific one for high-power viewing of its many features. But before you get too deeply involved in this, take some time to scan the region at low power. You'll see many small features scattered between the large craters and plains that you may wish to inspect at high magnification. Soon you'll be returning to this area and know it as you know an old friend. ☐

Michael T. Kitt is an experienced lunar observer and author of The Moon: An Observing Guide for Backyard Telescopes *(Kalmbach, 1992).*

Lee C. Coombs


Mare Nubium
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Birt
Arzachel
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Some prices in retail stores may vary.

ORION TELESCOPE CENTER

THE WORLDS' LARGEST CATALOG OF TELESCOPES, BINOCULARS & ACCESSORIES —

Call Toll-Free For Your Free Giant Color Catalog Today!

Packed with a huge selection of quality telescopes, binoculars and accessories, all at low discount prices! Hundreds of exclusive items you won't find anywhere else.

Only a small selection of our products are in this ad! Be sure you have our catalog.

CELESTRON

Telescopes, Binoculars and Accessories —

See Catalog For Our Full Selection.

Orion is the #1 source for Celestron products! Our low, low prices can really save you a bundle! Whether you are considering a big telescope or a small one, or a binocular or accessory, chances are Orion has just what you are looking for. Celestron telescopes are available with a variety of mounts, including German-style equatorial or fork mounts, with a wide range of available drive systems.

A huge selection of models, in all price ranges, available for immediate delivery!

Schmidt-Cassegrains — Celestron pioneered these fantastic instruments, and has an enviable reputation for building unsurpassed, exquisitely fine Schmidt-Cassegrain optical systems.

Refractors — Celestron's high-performance refractors are superb all-purpose telescopes, for astronomical or terrestrial observing. Built to standards that far exceed other telescopes in their class.

Reflectors — Celestron's popular reflector telescopes feature superior optical performance and full-featured, precision equatorial mounts which permit a full complement of optional accessories including electronic drive systems.

TeleVista II 60mm Refractor

Equally at home viewing the rings of Saturn or boats across the bay. Quality 25mm (28x) 1.25"eyepiece, all metal optical tube and yoke mount, finder scope, adjustable tripod, diagonal prism.

#9075 **$199** (8.97)

Sky Explorer II 60mm Refractor

Ideal for lunar and planetary study, plus it's a powerful terrestrial telescope. 900mm f.l, 6x30 finder; star diagonal ; two eyepieces, equatorial mount; setting circles; tripod; and lighted accessory tray.

#9076 **$329** (13.22)

SpaceProbe II 4.5" Reflector

Great 4.5" f/8 reflector, ideal for planetary and deep space. Equatorial mount, slow motion controls, setting circles. 6x30 finder plus 25mm (36x) and 9mm (100x) 1.25" eyepieces. Deluxe tripod.

#9078 **$388** (22.19)

Sky Explorer II 80mm Refractor

Perfect for planetary and lunar observation. Bigger equatorial mount than competitive models, two 1.25" eyepieces, 6x30 finder, star diagonal, deluxe tripod and accessory tray.

#9077 **$488** (32.66)

New! Orion 6", 8", 10", & 12.5" Dobsonian Telescopes

SPECIAL INTRODUCTORY PRICES!

#9901	**$299** 6" f/8	#9903	**$549** 10" f/5.6
#9902	**$399** 8" f/6	#9904	**$699** 12.5" f/4.8

Prices include precision helical focuser and 25mm Sirius Plossl eyepiece — an $87 value!

These prices are not a misprint! Ideal for both beginners and advanced astronomers, these great new scopes offer high performance and lasting value. Precision 1/8-wave accurate reflector optical systems are ideal for both planetary and deep space observation. Image quality rivals scopes selling for four times their price. Huge light grasp for superb images of faint celestial subjects. See the Great Nebula in Orion in incredible detail. Get lost in the cloud belts of Jupiter. Lunar craters so detailed, you'll think you're in orbit!

Precision Dobsonian-type mounts are the finest in their class. Teflon zero-backlash bearings make it a breeze to track objects without wobble or vibration. Much more stable than comparable equatorial scopes. Lightweight, rugged, easy to transport and set up. Complete instruction manual.

Built to last a lifetime. Primary and secondary mirrors are aluminized and SiO overcoated for durability. Cabinet-quality laminate finish resists dirt and moisture.

Packing & UPS Shipping to any address in the 48 states: 6"—$39. 8"—$49 10" & 12.5" — call for charges.

DEEP SPACE EXPLORER

Incredible Value!

Shown with optional finder scopes

The 6" model is the ideal beginner's or family scope - and is incredibly low-priced. Weighing only 29 lbs. complete, it's easily moved or handled by anyone. The 8" model offers 77% more light grasp, but is still a reasonable 39 lbs. and is only slightly larger.

The 10" and 12.5" models are perfect for those who can observe from darker sky locations. While heavier and larger than the smaller models at 68 and 85 lbs., they offer tremendous performance for their low prices.

MONEY BACK
If you are not completely satisfied with your purchase from Orion, for any reason.
100% SATISFACTION
Just return it in new condition within 30 days after delivery for a full refund.
GUARANTEE

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800-447-1001
IN CALIFORNIA: 800-443-1001

Huge Selection of Astronomy Binoculars

New! 50mm Orion Observer™ II Binoculars - 7x, 10x, & 12x

Fine quality, moderately priced binoculars, excellent for both astronomy and daytime observation. Fully coated optics, unique hand strap for a secure and comfortable grip.

7x50 #9643 **$89.50** (4.44)
10x50 WA #9644 **$94.50** (4.44)
12x50 WA #9645 **$94.50** (4.44)

50mm Explorer™ Binoculars

Our newest high performance binoculars with BAK-4 prisms and Multi-Coatings. Great for both astronomy and daytime observation. Comfortable ergonomic body design.

7x50 #9306 **$117** (4.44)
10x50 #9308 **$127** (4.44)

50mm Adlerblick Binoculars

Incredible wide field eyepiece design. Fully Multi-Coated, BAK-4 prisms, and best special glass objective lenses make the 7x50 Adlerblick the arch rival of European brand binoculars selling for 3-4 times the price. Orion buys direct, saving you money. Includes deluxe hard case, lens caps and straps.

7x50 #9612, *10x50* #9610 **$287** (5.28)

Orion® 8x56 Mini Giants

56mm objective lenses gather over 2.5x the light of ordinary 7 x 35 binoculars. Perfect for viewing faint celestial objects, daytime viewing. Best Multi-Coated BAK-4 optics. 6° field of view. Standard model 33 oz. Rubber Armored for protection from bumps. Weighs 37 oz.

Standard Model #9504 **$147** (4.71)
Rubber Armored Model #9627 **$157** (5.07)

Orion® 70mm FMC Giants

The standard for hand-holdable astronomy binoculars. Fully Multi-Coated. 33% lighter—weighs only 58 oz.—yet the same brightness and 7mm exit pupil as our 11x80 MC model. Superior 'BCF' body design. Includes: soft rubber eyecaps, tripod mounting adapter, durable hard carrying case, lens caps and straps.

10x70 #9501, *14X70* #9594 **$299** (6.97)

80mm FMC Giant Binoculars

20% more light transmission than ordinary "fully coated" binoculars. Fully Multi-Coated optics and superior BAK-4 prisms provide fantastic contrast and greatly improved edge sharpness.

11x80 MC- Brightest, widest field available. Ideal for deep-space observation under dark skies. Hand-holdable.

#9502 **$379** (8.05)

16x80 MC- 45% higher power, excellent for astronomy and daytime observation. Tripod recommended.

#9496 **$389** (8.05)

20x80 MC- Highest power model perfect for smaller deep-space objects and long range daytime views. Tripod required.

#9498 **$399** (8.05)

10x70 Military-Spec Binoculars

Light enough to hand hold, yet powerful enough to bring in remarkable views of deep space celestial objects. With military-grade optics, for the highest degree of optical accuracy and mechanical ruggedness. Will last through a lifetime of use, even under the most extreme environmental conditions. Absolutely waterproof and fogproof. With built-in folding rubber objective lens shades/ dew caps. Includes deluxe case, photo tripod adapter. 7mm exit pupil. 5° field of view.

#9309 **$444** (7.29)

SuperGiant™ 100mm Binos

Gigantic, almost 4" lenses gather 156% of the light of 80mm binoculars. Individual eyepiece focus, fully Multi-Coated optics and BAK-4 prisms. Tripod mounting plate, metal-clad case. Weight 7.5 lbs., height 13.5".

14x100 #9495, ***25x100*** #9497 **$888** (29.00)
Shipped by FedEx only.

Observing Aids

NEW! Eyepiece/Accessory Cases

With patented unbreakable latches, die-cut foam inserts.
Inside Dimensions shown

11"x7"x3" #5951 **$17.95** (2.78)
12.5"x9"x5" #5952 **$26.95** (3.36)
16"x11"x5" #5953 **$46.95** (5.19)

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers —fit all Meade & Celestron 8" SCs
DC #3503, AC #3504 **$44.95** (2.98)

10" Dew Zappers—fit all Meade 10" SCs
DC #3506, AC #3508 **$49.95** (2.98)

12V DC Dew Gun.—#5601 **$19.95** (2.78)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.

8" Celestron/Meade SC #4200 **$39.95** (2.98)

Other sizes available for scopes 3.5" to 14" —See our catalog for details

Scope Saver Telescope Covers

Keep the dust and dew away with these waterproof nylon covers; drawstring closure with cord lock.

8"Model
#15130 **$33.95** (2.43)

10"-11" Model Fits Meade 10" and Celestron 11"
#15131 **$39.95** (2.43)

Ask about other sizes.

Components

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors

Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/4.5, 12.5" f/6.

Pyrex Low Expansion Mirrors

Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis. *See catalog for pricing.*

Finder Scopes

These are high-quality finders at incredibly low prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White enameled metal tube.

6x30mm — Same unit used on $1000+ "big name" telescopes. With 2-ring bracket, fits scopes 6"-12". #13023 **$44.50** (3.41)

6x30mm Right Angle — 90° prism for right-angle viewing. Includes bracket. #13021 **$59.95** (3.41)

NEW! 8x50mm — 2.7x light grasp of 30mm models. Bright 6.25mm exit pupil. #7090 **$64.50** (3.41)

NEW! 8x50mm Illuminated—Wireless illuminator with adjustable brightness. #7092 **$94.50** (3.41)

NEW! 9x60mm — 44% more light grasp than 50mm models. #7091 **$99.50** (3.41)

NEW! 9x60mm Illuminated—Wireless illuminator with adjustable brightness. #7093 **$134.50** (3.41)

Mounting Brackets - 2-ring design with non-marring adjusting screws. Fits any scope 6" and over including Celestron & Meade SCs

8x50mm bracket #5143	**$27.95** (2.98)
9x60mm bracket #5041	**$32.95** (2.98)

Rack-and-Pinion Focusers

Finest in their class. Diagonal-cut plated brass racks, oversized knurled knobs, long focus travel.

1.25" #13007 **$49.95** (2.98)

2.0" includes 1.25" adapter.
#13003 **$89.95** (3.95)

NEW! Low-Profile Focusers

Perfect for fast optical systems. Ideal replacements for "Odyssey" scopes.

1.25"-#13014 **$39.50** (2.45)
2.0" - #13016 **$59.50** (2.98)

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection.

Astronomer's Flashlight	#5701	**$9.95** (1.79)
Nitewriter Pen	#5709	**$8.95** (1.79)
Hands-Free Flex Light	#5707	**$17.95** (2.43)
Starlite LED Flashlight	#5714	**$24.95** (2.43)
Celestron LED Flashlight	#5720	**$19.95** (2.43)

Observer's Chairs

Standard Model—Adjustable height center column and padded seat.
#5935 **$39.95** (4.70)

Deluxe Model—Built for professional musicians. Extra heavy duty.
#5934 **$89.95** (8.02)

Accessories See Our Catalog for Even More!

45° Erect Image Diagonal Prisms

See the world as it really is with Orion's 45° erect image diagonal. Ideal for all refractors and compound telescopes used for terrestrial viewing.

1.25" Diagonal #8790
.965" Diagonal #8791
Hybrid 1.25"/.965" Diagonal #8792

$44.95 ea. (3.45)

90° Star Diagonal Prisms

Orion's multi-coated diagonals let you view at a right angle from the direction your telescope is pointing. The image is backward. Ideal for refractors and Schmidt-Cassegrains used for astronomical viewing.

1.25" Star Diagonal
#8763 **$43.95** (2.98)

.965" Star Diagonal
#8761 **$26.95** (2.98)

Hybrid 1.25"/.965" Star Diagonal
#14008 **$31.50** (2.98)

2" Prism/Mirror Diagonals

2" Prism Diagonal–Absolutely the finest quality multi-coated 2" prism for highest light transmission.

For refractors #8770
For Schmidt-Cass. #8771
$199 ea. (4.71)

2" Mirror Diagonal–Affordable, high-quality star diagonal.
For refractors #8773
For Schmidt-Cass. #8772 **$99.95 ea.** (3.45)

Universal Camera Adapters

For prime focus or eyepiece projection astrophotography.

.965" #5268 **$26.95** (2.98)
1.25" #5264 **$29.50** (2.98)
Hybrid 1.25"/.965" #8782 **$29.50** (2.98)

Variable Power Camera Adapter

Allows variable projection distances during eyepiece projection photography. For 1.25" eyepiece holders.

#5262 **$38.50** (2.98)

Tele-Extenders

For high powered photography with your Meade, Celestron 4", 8", 10", 11", 14" Schmidt-Cassegrain.

Standard Tele-Extender #5125 **$27.95** (2.98)
Variable Tele-Extender #5127 **$37.95** (2.98)

T-Adapters

Threads to rear cell of telescope, requires t-ring for your camera model.

for SC #5116, *for C-90* #7115 **$26.50** (2.98)

T-Rings

Available for many different camera types, call toll-free or see our catalog for your particular model.

Multi-Function Focal Tester

Allows easy, accurate, ultra-sharp focusing, essential for astrophotography.

#7109 **$159** (4.19)

Tripods

Bogen/Velbon/more!
Huge selection of tripods available, for telescopes, spotting scopes and giant binoculars. Choose from assembled models or mix-and-match pan heads and tripod legs, sold separately. See our catalog for details.

Orion Slow Motion Adapter

Attaches to your photo tripod pan head. 2 slow motion control knobs to make precision adjustments in altitude and altazimuth. Very handy for tracking planets, the Moon, etc. with refractor telescopes and small spotting scopes. Attaches with a standard 1/4-20 thread.

#7012 **$44.50** (2.98)

Extension Cable for Slow Motion Control

12 3/4" flexible cable, for tracking at high powers. Buy 2, one for each axis.

#5014 **$15.95 each** (2.43)

StereoScope Viewer

For comfortable two-eyes-open observing. You won't believe the views! Threads securely to the rear cell of your telescope. Requires two identical eyepieces.

#9720 **$479** (5.71)

f/6.3 Reducer/Corrector

Get f/6.3 performance from your f/10 Schmidt-Cassegrain.

#5120 **$169** (3.67)

New! Sky Wizard™

Electronic Finder & Sky Catalog

Let Sky Wizard do the work, while you relax and have fun observing!

Orion's new Sky Wizards are electronic marvels that will put the magic back in your astronomical observing!

- Find any celestial subject in 15 seconds!
- One minute setup — no polar alignment or levelling.
- Observe hundreds of objects in a few relaxed hours — without using star charts!
- For ANY telescope, with or without a motor drive. *Even altazimuth or Dobsonian scopes!*
- Digital display of celestial coordinates (RA & Dec).
- Built-in electronic sky catalog — find subjects by their common catalog name, not their coordinates. Complete with object descriptions.
- Powered by a single 9v battery. Weighs just 6 oz!

Complete system requires Sky Wizard Model 1 or 2 and a telescope installation package, sold separately.

Encoders and cables available separately for custom installations. Call for details.

Sky Wizard Model 1
Includes the Messier Deep Space Catalog of 110 objects, 28 bright stars, and the planets.
#7801 **$219** (4.11)

Sky Wizard Model 2
Huge 2100+ object database, plus a user catalog to store 27 objects of your choice.
#7802 **$319** (4.44)

Installation Packages
Includes 2 encoders, all required mounting hardware and brackets, connecting cables, and complete illustrated instructions.

Celestron Super Polaris	#27100	**$207** (5.29)
Celestron Ultima 8" & 11"	#27101	**$177** (5.29)
Celestron Classic 8" & Powerstar 8"	#27102	**$177** (5.29)
Meade 8" & 10"	#27103	**$202** (5.29)
Dobsonian (fits Coulter and most others) Call for stock # for your model		**$177** (5.29)

Installation packages available for other telescopes.

Orion Off-Axis Guider

Allows you to observe a guide star during photography. Multi-coated.

#5144 **$49.95** (3.45)

Orion UltraGuider

Wide-range lateral prism adjustment; precision helical focusing; adjustable camera focal plane position.

#5139 **$119** (4.19)

110v Motor Drive for Refractors

Fits Orion equatorial mounts, many others. Plugs into any standard AC outlet.

#17001 **$69.95** (3.95)

12 Amp Hour Porta Pac Battery

Ideal for high power-consuming accessories. With carrying case. Weighs only 10 lbs.

#2354 **$109** (8.97)

Filters

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.

For 8" SCs #7713 **$144** (4.05)
For 10" SCs #7715 **$162** (4.05)

Many other sizes available—see our free catalog for details.

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664, 1.25" #5662 **$14.95 ea.** (2.43)

Color Eyepiece Filters

Highest quality precision-ground optical glass. Fully anti-reflective coated. Solar system observations are dramatically improved. Thread into the barrel of any standard eyepiece, or directly into a universal camera adapter.

.965" Basic Set of 4 Filters #80A Blue, #58 Green, #25 Red, #15 Yellow.
#5510 **$39.95 set** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow.* #5514
1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue.* #5516
1.25" Advanced Set of 4 *#8 Light Yellow, #23A Light Red, #38A Deep Blue, #56 Light Green.* #5570
$44.95 each set (2.98)

Deluxe Set of 8 Filters for 1.25" Includes all the filters in our basic and expansion filter sets.
#5517 **$79.95 set** (3.45)

Full Set of 12 Filters for 1.25" Includes Basic Set, Expansion Set, Advanced Set.
#5575 **$119 set** (3.67)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow.
#5513 **$84.95 set** (3.96)

Individual .965", 1.25" & 2" Filters- Many colors available, see our catalog for details.

SkyGlow™ Light Pollution Filters

Enhance your viewing of faint deep sky objects with the best broadband light pollution filter you can buy. Our SkyGlow absorbs frequencies emitted by city lights, allowing transmission of the rest of the visible spectrum, yielding dramatic results.

SkyGlow Broadband Filters—Photographic and Visual
For use in slight to moderately light polluted areas.

1.25" Broadband Filter–fits 1.25" eyepieces. #5660 **$54.95** (3.45)
SC Broadband Filter–fits rear cell of Meade & Celestron SC scopes. #5658 **$79.95** (3.45)
52mm Broadband Filter–For 52mm camera lenses, (Adapter rings available for other diameters.) #5668 **$74.95** (3.45)
2.0" Broadband Filter–fits 2" eyepieces. #5659 **$89.95** (3.45)
.965" Broadband Filter–fits .965" eyepieces. #5661 **$39.95** (2.98)

SkyGlow UltraBlock Filters–Visual Only
For severely light polluted areas and faint nebulae.

1.25" UltraBlock Filter–fits 1.25" eyepieces. #5654 **$79.95** (3.45)
SC UltraBlock Filter–fits rear cell of Meade & Celestron SC scopes. #5656 **$109** (3.67)

Eyepieces & Barlows

✧ *Sirius*™ *Plössl 1.25" Eyepieces*

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

You could pay nearly twice the price for 'famous name' Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces!

Sirius Plössls are top-quality, 50° apparent field eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of reflector, refractor and catadioptric telescopes. The Plössl design is renowned for its fantastic performance and has in recent years become the standard by which all other eyepieces are compared.

Each eyepiece is of the classic 4-element Plössl design. Every air-to-glass surface is fully Magnesium Fluoride anti-reflection coated. All lens edges are blackened in the same way as expensive military optics, to further eliminate any scattering of stray light and to maximize contrast.

The optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

We guarantee that you'll be impressed with the performance of the Sirius Plössls, even when compared to the more expensive name-brand Plössls.

25mm #8530, ***17mm*** #8531,
10mm #8532, ***7.5mm*** #8533

Sale! $47.50 each (3.45)

Set of 4 in foam-lined case
#8534 **Sale! $177** (4.71)

Explorer .965" & 1.25" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Three different optical designs are incorporated, to maximize efficiency in the various focal lengths. Black anondized, internally blackened, threaded for filters (except 40mm .965").

.965 Orthoscopic
5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583
$49.50 each (2.98)

.965 Kellner
18mm #8584, **25mm** #8585
$37.50 each (2.98)

.965 Achromatic Huygenian
40mm #8586
$37.50 (2.98)

1.25" Orthoscopic
5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526
$54.50 each (2.98)

1.25" Kellner
6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512
$43.50 each (2.98)

Superb Ultrascopic™ Eyepieces

Unlike other premium eyepieces, Orion Ultrascopics offer complete multi-layer coatings on ALL surfaces, for superior light transmission and contrast. Modern 5- and 7-element designs for pinpoint star images and breathtaking detail. Wide 52° field of view. Guaranteed to beat other brands selling for much more! Unsurpassed high-performance design!

Medium-High Power 5-element
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572
$74.95 ea. (3.45)

Wide Field 5-element
25mm #8564 **$89.95** (3.45)
30mm #8562 **$94.95** (3.45)
35mm #8560 **$99.95** (3.45)

High Power 7-element *—Long Eye Relief*
5mm #8574, **3.8mm** #8576
$84.95 ea. (3.45)

MegaVista 1.25" & 2" Eyepieces

These outstanding eyepieces feature a 7-element design and incredibly sharp, fully multi-coated optics. The long eye relief and integral rubber eyeguards make these ideal for eyeglass wearers. The extra wide field of view (67°-70°) provides stunning images, perfect for deep space observing.

10.5mm 1.25" #8552 **$154** (3.67)
16.8mm 1.25" #8554 **$149** (3.67)
34mm 2" #8587 **$199** (3.67)
40mm 2" #8588 **$229** (3.67)

Illuminated Reticle Eyepieces

Orion offers 4 versions of the illuminated reticle eyepiece, a neccessity for long exposure astrophotography and very useful for polar alignment. All have 1.25" barrels.

12.5mm Plossl Illuminated Reticle
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 **$109** (3.45)

12mm Kellner Illuminated Reticle
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 **$79.95** (3.45)

9mm Orthoscopic Illuminated Reticle
Adjustable brightness illuminator. 'Bull's-eye within crosshairs' reticle. Needs 2 SR-44 batteries, not included.
#8488 **$109** (3.67)

6mm Orthoscopic Illuminated Reticle
Unique adjustable reticle system. Variable brightness. Needs 2 SR-44 batteries, not included.
#8487 **$129** (3.67)

SR-44 Batteries #2360 **2 for $3.49** (1.79)

UltraZoom™ 7–21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.

#8556 **$159** (3.67)

See our free catalog for a fantastic selection of name-brand eyepieces!

CELESTRON TeleVue

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.
.965" #8740 **$34.95** (2.98)
1.25" #8746 **$44.95** (2.98)
2" #8724 **$89.95** (3.95)

Ultrascopic 2x Fully Multi-Coated Barlow
3-element Ultrascopic lens for superior images and precise color correction. Fully multi-coated optics, black anodized barrel. 1.25 barrel.
#8750 **$59.95** (3.45)

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 **$54.95** (3.45)

Shorty Barlows
The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly, and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.

.965" #8710 **$46.95** (2.98)
1.25" #8711 **$54.95** (3.45)

CALL TOLL-FREE
800-447-1001
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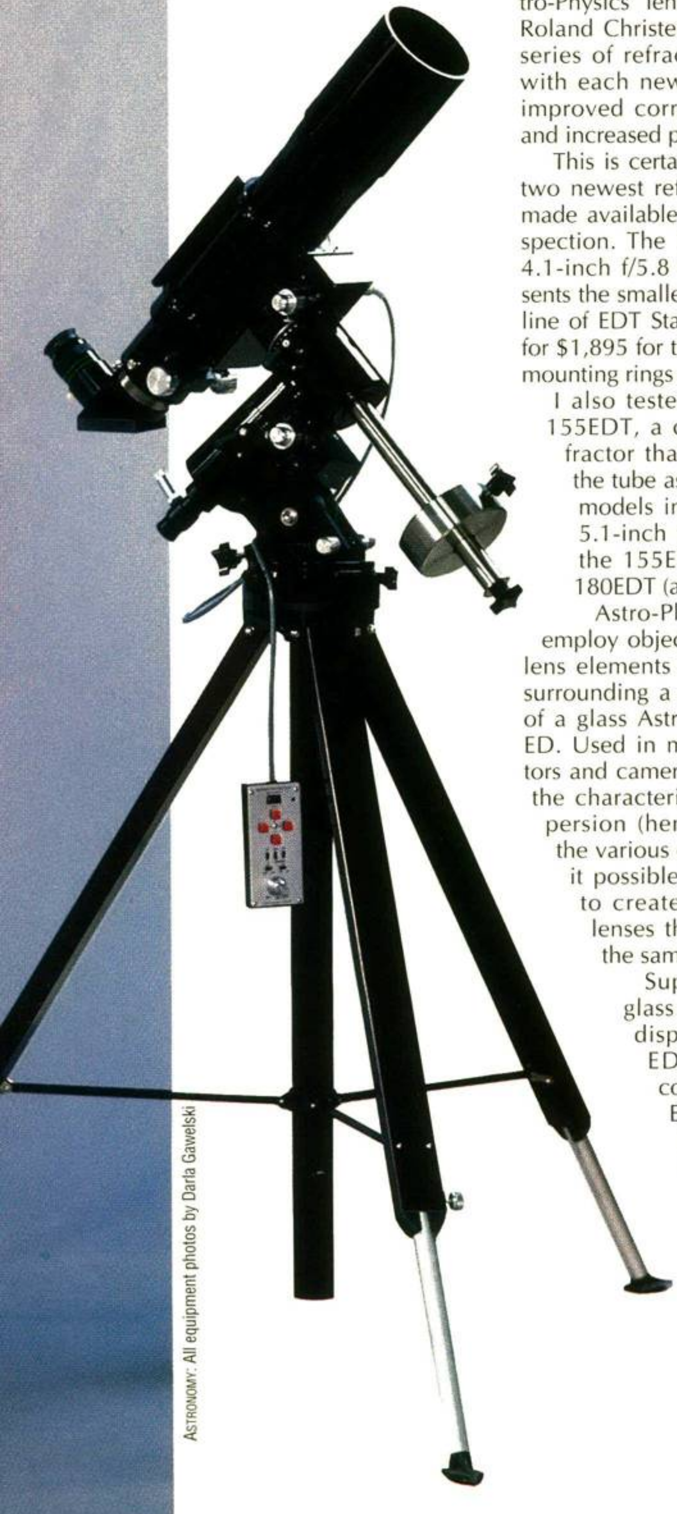
STARFIRE EDF

ASTRO-PHYSICS REFRACTORS

BIG & SMALL

Astro-Physics' new line of refractors promises high-resolution, color-free optics on solid mountings. Our testing found they amply delivered on that promise.

by Alan Dyer



Astronomy: All equipment photos by Darla Gawelski

Refractor telescopes have gained a loyal following in the last few years. And for good reason. The new apochromatic, or "color-free," refractors now offered by several manufacturers can provide sharp, contrasty images that are textbook perfect.

One of the key players in the premium refractor market is Astro-Physics. Its telescopes have undergone a succession of improvements since their introduction in the mid-1980s. Spurred on by the availability of ever more exotic types of glass, Astro-Physics' lens designer and owner Roland Christen has created several series of refractors over the years, with each new generation offering improved correction of false color and increased portability.

This is certainly the case with the two newest refractors Astro-Physics made available to Astronomy for inspection. The 105EDT Traveler is a 4.1-inch f/5.8 telescope that represents the smallest in the Astro-Physics line of EDT Starfire refractors. It sells for $1,895 for the tube assembly with mounting rings and case.

I also tested the brand-new f/7 155EDT, a compact 6.1-inch refractor that sells for $4,495 for the tube assembly. Other Starfire models include the 130EDT (a 5.1-inch f/8), an f/9 version of the 155EDT, and the massive 180EDT (a 7.1-inch f/9).

Astro-Physics EDT refractors employ objective lenses with three lens elements — two crown lenses surrounding a center element made of a glass Astro-Physics calls Super ED. Used in many premium refractors and camera lenses, ED glass has the characteristic of extra-low dispersion (hence the name ED) of the various colors of light, making it possible for optical designers to create doublet and triplet lenses that bring all colors to the same focus.

Super ED is a premium glass with a slightly lower dispersion than standard ED but with a higher cost. The grade of Super ED Astro-Physics uses in most of its current refractors is called FPL52 (formerly known as FK02) and has a dispersion index of 90 versus 82 for ED — the higher the number the lower the dispersion. However, the new f/7 155EDT reviewed here uses a new ED glass called FPL53. Its dispersion index of 95 allows Astro-Physics to create even faster lenses without sacrificing correction.

In addition to the EDT series of refractors, Astro-Physics also offers an EDF line. These top-end instruments come with a giant 4-inch focuser and 4-inch field-flattener lens (hence the F designation) for astrophotography on film sizes up to 4x5 inches. The two current EDF models include a 4-inch focuser version of the 6.1-inch f/7 and the giant 206EDF (an 8.1-inch f/8). While the 8.1-inch EDF is currently the top of the Astro-Physics' line, its $12,500 price tag for the tube assembly alone puts it clearly in the "dream telescope" class even for devoted lovers of lenses.

The Mountings

High-resolution optics demand ultra-steady mounts. There's no point in having a telescope able to resolve detail within the Red Spot of Jupiter if the entire image of Jupiter wobbles all over the field with every breath of wind and every touch of the focuser.

I examined the three newest mounts Astro-Physics recently introduced to its lineup: the portable Model 400 for its 4- and 5-inch refractors, the medium-weight Model 600E for the 5- and 6-inch telescopes, and the massive Model 1200 which Astro-Physics recommends for their 7- and 8-inch scopes. (Astro-Physics also offers an older mount, the Model 800, midway in size between the 600E and 1200.)

Each of the three mounts I examined was an outstanding example of fine craftsmanship. Assembly was quick and convenient. Fit and finish were superb. The motions were smooth, the locks firm and solid. And the all-important steadiness of the mountings was as good as I've seen on any mountings of similar size and load-carrying capacity.

Polar alignment of even the big mounts was a snap. The altitude and azimuth adjustments on the bases of the mounts made it easy to zero in

TWO OF THE NEWEST REFRACTORS on the market are the 6.1-inch f/7 EDT (far left) and the 4.1-inch f/5.8 EDT from Astro-Physics (near left). The large refractor is shown on Astro-Physics' massive Model 1200 mount. The smaller 4.1-inch is on the portable Model 400 mount and Davis and Sanford tripod.

on the celestial pole. The optional boresight polar alignment scopes worked extremely well. They provided quick alignment accurate enough to prevent any declination drift from showing up on film even in 45-minute-long exposures near the pole.

Each Astro-Physics mount features dual-axis stepper motor drives that operate directly from any 12 volt DC source. An output jack on each mount head provides a source of 12 volts for plugging in accessories such as anti-dew heater coils or illuminated-reticle eyepieces. A rheostat on the hand controller allows you to vary the output voltage from this accessory jack.

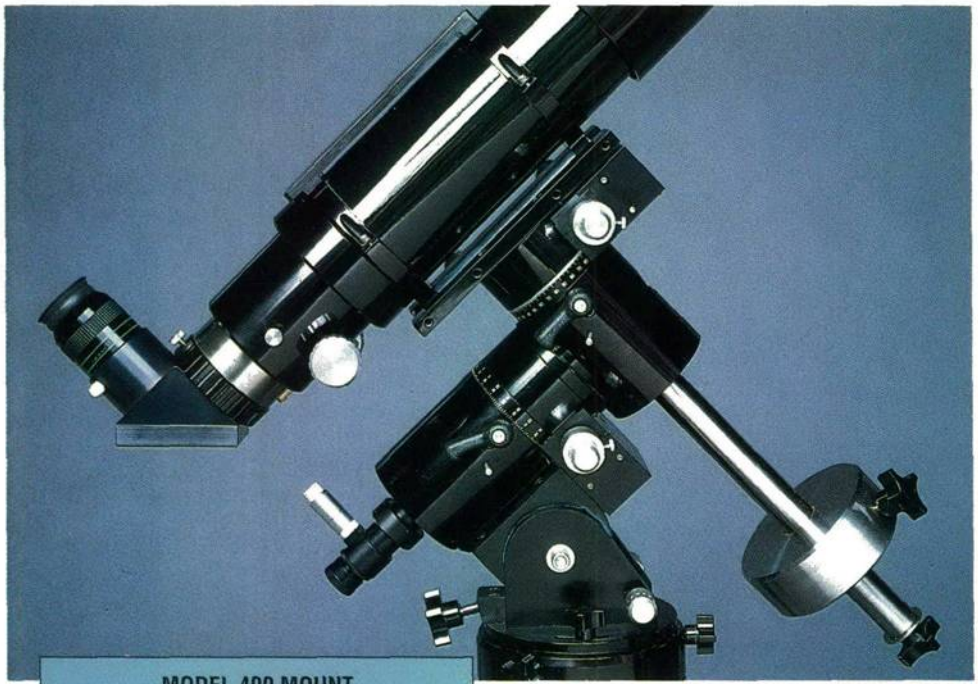
Each mount comes with a nearly identical hand controller with 2x, 8x, and 16x speed controls for guiding and centering on objects. One glitch was that the 2x and 16x speed settings were mislabeled on all the hand controllers; the 2x setting was really the 16x and vice versa. A note in the instruction manuals warns you about this error.

The hand controllers also provide a choice of three tracking rates (sidereal, solar, and lunar) and switches that reverse the way the telescope moves when you hit the direction buttons. These allow you to set the hand controller buttons so that no matter how the mount is oriented, the image moves in the direction that seems most logical — the button on the left moves the image to the left, for example. A switch for Southern Hemisphere operation rounds out the motor controls.

The controllers of all three mounts also offer a computer-style jack for connecting a Santa Barbara Instruments' ST-4 autoguider. A convenient feature is that this jack also provides a source of 12-volt power for the ST-4. This allows one handy cable that Astro-Physics supplies to both link the telescope and ST-4 and provide power to the ST-4, helping to reduce cable clutter.

Lightweight and Portable: the Traveler and 400 Mount

The smallest Astro-Physics telescope is the versatile 4.1-inch f/5.8 Traveler, also known as the 105EDT. As its name suggests, this telescope is designed for portability. Its 19-inch long, 9-pound tube fits into a case small enough to qualify as carry-on baggage on an aircraft. (A soft-sided case comes with the Traveler for this very purpose.) The Traveler includes Astro-Physics' standard 2.7-inch focuser, a smooth and precise unit with no image shift. In fact, I could hear

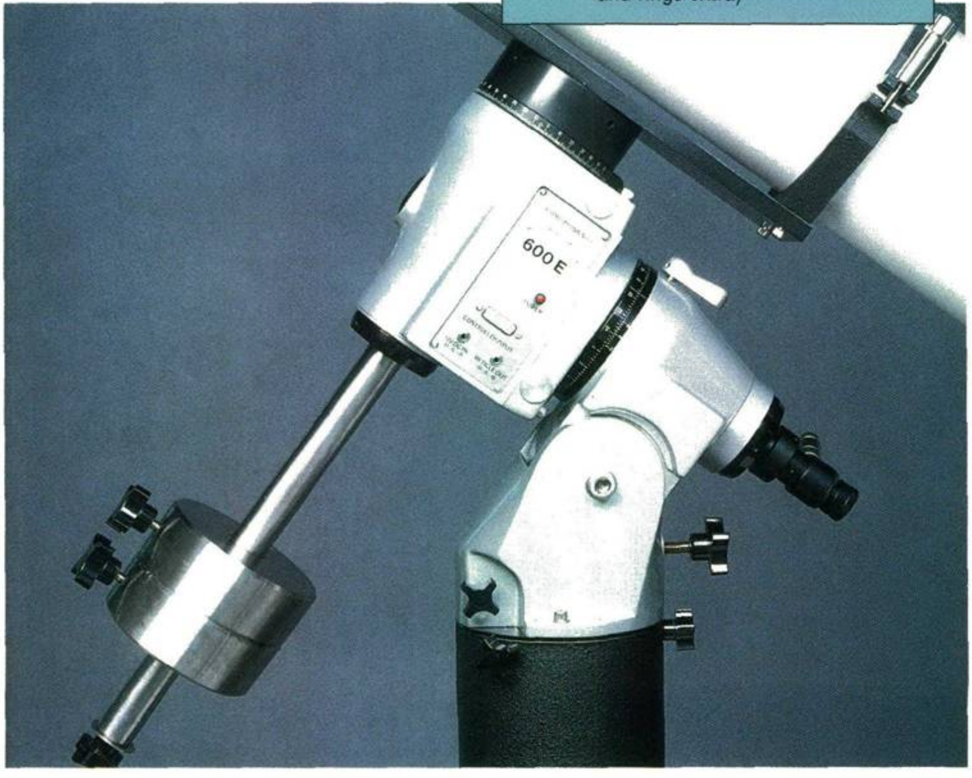


MODEL 400 MOUNT

Can handle up to	5" refractor, 6" reflector, and 8" SCT
Weight of head	20 lbs.
Weight of D&S tripod	11 lbs.
Measured tracking error	40 arcseconds
Measured damping time	2 seconds
Price with D&S tripod (counterweights and rings extra)	$1,650

MODEL 600E MOUNT

Can handle up to	6" refractor, 8" reflector, and 12" SCT
Weight of head	27 lbs.
Weight of pier	32 lbs.
Measured tracking error	15 arcseconds
Measured damping time	2 seconds
Price with pier (counterweights and rings extra)	$2,885



air hissing out as I racked the focuser in, a testament to the tight machining tolerances employed on this focuser. The focuser also features 12 light baffles down the inside of its tube to block stray light.

The telescope tube itself has 12 additional light baffles. The black anodized and painted tube is machined from solid aluminum stock, making for a rugged assembly designed to withstand the rigors of travel. I had the opportunity to test this feature when I took the Traveler to Chile for a Southern Hemisphere astrophotography session. For my trip I packed the telescope in a foam-lined, hard-sided camera case and sent it off to endure the trip as checked luggage. It survived eight plane changes with no trouble at all.

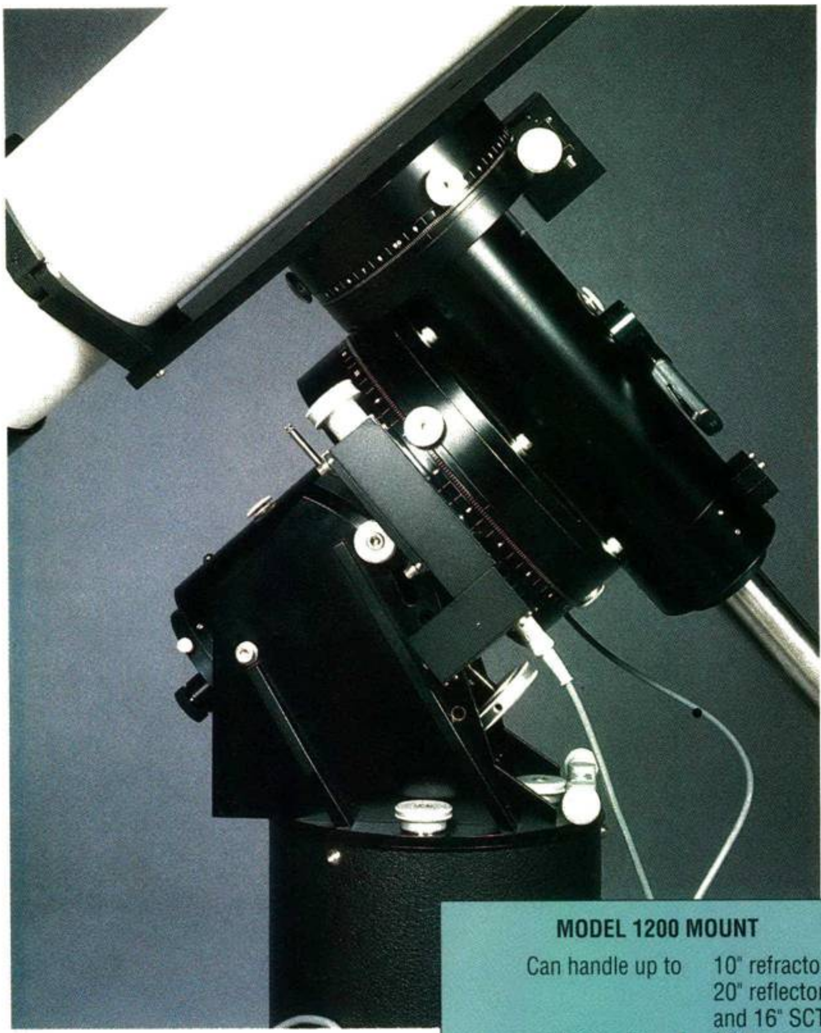
The optical quality of the Traveler proved superb. Images of even the brightest objects — tough tests such as Venus and the limb of the Moon — were completely color-free, a remarkable achievement in an f/5.8 refractor and a tribute to how far lens technology has come in the past few years. There was no sign of spherical aberration or on-axis astigmatism. Star images looked textbook perfect in focus and on either side of focus. The fully multicoated optics also provided very bright images for the aperture.

On prime focus photos at f/5.8, the Traveler exhibited a mild curvature of field, a property inherent in many fast refractor designs. As a result, stars at the corners of a 35mm frame appeared slightly elongated due to astigmatism. Astrophoto perfectionists can purchase an optional Field Flattener lens ($295) to correct this. Although a luxury for 35mm photography, the Field Flattener is a necessity for photos with medium-format 6x7cm cameras. A better option for 35mm deep-sky shots is Astro-Physics' new 0.75x Flat Field Telecompressor ($250). It reduces the effective focal length of the Traveler from 610mm to 460mm and speeds up the focal ratio from f/5.8 to f/4.4. It also flattens the field; test photos showed pinpoint stars across a 35mm frame. Unfortunately, the telecompressor can't provide an image circle large enough to fill the frame of large format cameras.

The Traveler's matching Model 400 mount is also made of machined and black anodized aluminum. The unit I tested came on a lightweight but very capable camera tripod made by Davis and Sanford. This tripod-and-mount combination (without counterweights) weighs an easy-to-handle 31 pounds and is ideal for users who value portability. With the Davis and Sanford tripod, vibrations damped out in about 2 seconds. For those looking for a steadier platform and willing to give up some portability, Astro-Physics offers the 400 mount on a tall but solid hardwood tripod that weighs an extra seven pounds.

The 400 mount includes smooth, manual slow-motion controls in both axes. Operating these requires disengaging a clutch ring and then engaging the clutch again when you want the electric drives to take over.

Tracking accuracy for the 400 was very good, exhibiting about a 40-arcsecond periodic error, comparable to other small premium mounts. The gradual nature of the periodic error drift over a $7^1/_2$-minute-long cycle made it effortless to guide out when doing deep-sky astrophotography. At the 2x guiding speed, there was a slight backlash in declination: After moving the scope in one direction in declination and then hitting a declination button to move it back the other way, there was a delay of about five seconds before the mount would respond. Movement in right ascension, the direction most guiding correction is required during



MODEL 1200 MOUNT

Can handle up to	10" refractor, 20" reflector, and 16" SCT
Weight of head	72 lbs.
Weight of pier	50 lbs.
Measured tracking error	10 arcseconds
Measured damping time	1 second
Price with pier	$5,065

(includes digital encoders;
counterweights and rings extra)

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8X
SOL
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16X
2X
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MAX
QUARTZ FREQUENCY CONTROL

THE HAND CONTROLLERS for all three mounts are similar and offer three tracking speeds, three guiding/centering speeds, and reversing switches.

ASTRONOMY: Alan Dyer

THROUGH THE 155EDT: The 1,100mm focal length of the 6.1-inch f/7.1 EDT produces a field of 1.8°x1.2° on a 35mm frame. Test photos such as this 45-minute shot of M81 and M82 showed pinpoint stars across the frame.

THROUGH THE 105EDT: When coupled with the optional Astro-Physics Telecompressor, the Traveler produces a field of 4.3°x2.8° on a 35mm frame, with stars sharp corner to corner. This is a 15-minute exposure of M8 and M20 at f/4.4.

ASTRONOMY: Alan Dyer

astrophotography, was instantly responsive in either direction.

Big Glass: the 155EDT

At the other end of the Astro-Physics line is the new 155EDT. This 6-inch class refractor provides the same level of superb color correction as previous Astro-Physics' 6-inch refractors did, but the use of the new Super ED glass allows Astro-Physics to produce this scope in a faster f/7.1 focal ratio, excellent for deep-sky astrophotography. With its relatively stubby 40-inch-long tube (not counting the detachable dewcap) the 155mm f/7 EDT is probably the most compact 6-inch apo refractor on the market. And perhaps the most versatile. It can perform as an astrographic lens, as a wide-field deep-sky observing instrument, and as a lunar and planetary telescope. The optional telecompressor adds to the versatility by turning this 1,100mm-focal-length f/7.1 instrument into an 840mm-focal-length f/5.4 telescope.

The 155EDT comes with Astro-Physics' standard 2.7-inch focuser, which will allow prime focus photography with 35mm and 6x7cm cameras. However, astrophotography diehards who wish to pursue large-format photography can order the 155EDT with the 4-inch focuser and 4-inch-diameter field flattener lens. Fitted with this combination, the 155EDF, as it is then called, sells for $6,400 for the tube assembly.

Optical performance of the 155EDT was impressive. It produced nary a trace of false color even on Venus. Equally impressive, this scope provided superb images as soon as it was set outside. Even in sub-freezing temperatures, image quality, though not perfect at first, was surprisingly sharp from the start. In cold weather, after a modest settle-down time of 30 minutes, in-focus star images were textbook Airy disks with a well-defined first diffraction ring and a trace of a second outer ring. There was no sign of spherical aberration, lens figure changes, heat plumes, or distorted Airy disks due to tube turbulence.

Middleweight Mount: the Model 600E

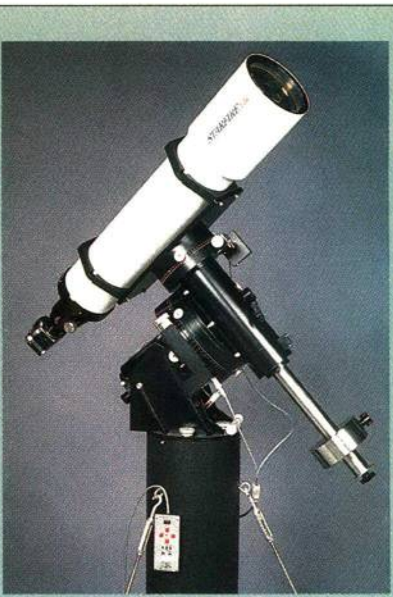
The most practical choice in the Astro-Physics stable for mounting the 155EDT and other 5- and 6-inch refractors is the Model 600E mount. Boasting recently revamped electronics, the 600E has all its motors enclosed within the mount head and most of the electronics within the hand controller unit. The mount head sits on a 6-inch-diameter portable pier that can be ordered in one of three heights: 48, 58, or 68 inches. The entire mount (head, 48" pier, legs, and tension rods) weighs 59 pounds, a hefty package but possible to carry outside as a single unit.

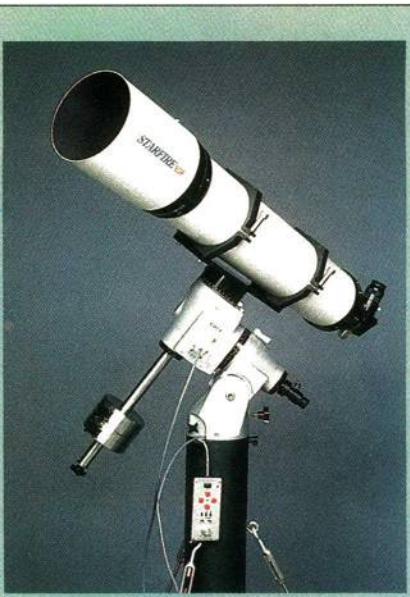
As with all Astro-Physics mounts, setting circles are standard and the right ascension circle is driven, eliminating the need to reset the RA circle every time you want to dial up a new object. As with the Model 400 mount, the RA and declination locks are levers that lock tight even if the mount is out of balance or carrying an overweight load.

There are no manual slow motions on the 600E mount. Fine adjustments to positioning must be done with the motor drives. While the 400 mount offers a quick-release dovetail bracket to attach telescope tubes, the 600E

ASTRO-PHYSICS 155EDT f/7.1 REFRACTOR

Aperture	6.1 inches
Focal length	1,100mm
Field on 35mm film frame	1.8°x1.2°
Field with Telecompressor (35mm frame)	2.4°x1.6°
Field on 6x7 film frame	3.5°x3°
Weight of tube	22 lbs.
Length (dewcap retracted)	40 inches
Price of tube assembly	$4,495
Price with mount:	
Model 600E & portable pier (right)	$7,701
Model 1200 & portable pier (left)	$9,881

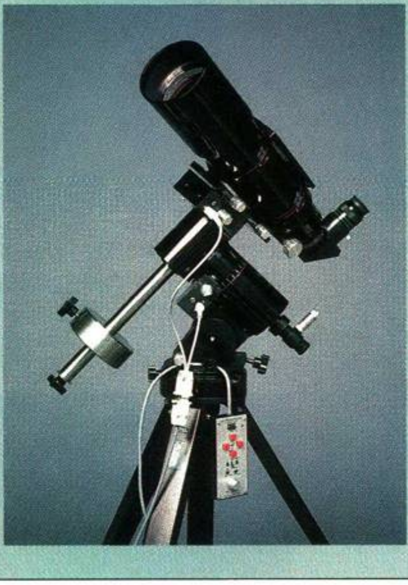




ASTRO-PHYSICS 105EDT f/5.8 REFRACTOR

Aperture	4.1 inches
Focal length	610mm
Field on 35mm film frame	3.3°x2.2°
Field with Telecompressor (35mm frame)	4.3°x2.8°
Field on 6x7 film frame	6.4°x5.5°
Weight of tube	9 lbs.
Length (dewcap retracted)	19 inches
Price of tube assembly	$1,895
Price with Model 400 mount:	
With Davis and Sanford tripod	$3,623
With hardwood tripod (not shown)	$3,683

Astro-Physics, Inc., 11250 Forest Hills Road,
Rockford, IL 61115, (815) 282-1513



uses a flat plate to which you attach conventional tube rings for your size telescope.

Tracking accuracy was excellent, with a gentle periodic error of 15 arcseconds over a cycle of 7½ minutes. With the 155EDT attached, vibration damped out in 2 seconds.

The $2,885 price tag for the mount and pier alone (counterweights are extra) puts the Model 600E in the premium mount league. But its solid performance makes it a winner in the middleweight class.

Heavyweight Mount: the Model 1200

If the Model 600E isn't enough of a mount for you, try the Model 1200, Astro-Physics' new top-end mount. Make no mistake. This is a *big* mount, not for the faint of heart or weak of limb.

The 1200 mount head breaks apart into heavy but manageable pieces. The 39-pound polar axis base bolts to a massive 50-pound, 8-inch-diameter pier. A separate 33-pound declination axis assembly then bolts to the polar axis base. While the 1200 is theoretically portable, it will take a dedicated observer to regularly carry this massive mount to dark sky sites. (It takes about 30 to 45 minutes to set up the 1200 from scratch.) This is a mount best housed in a permanent observatory. But once set up, the 1200 gives you the impression it can withstand hurricane-force winds. It took a hard knock to even induce vibration in the big mount, and what little shake there was in the image died out in a second.

The locks on each axis consist of a set of three knobs that each need to be tightened down to lock up that axis. But even with the mount unlocked, there is enough tension on the motions that it takes a fair amount of force to swing the mount, a good feature when a heavy telescope is attached. The mount has to be considerably out of balance before it will slip by itself with the axes unlocked.

I tested the 1200 mount with the 155EDT, a telescope that didn't begin to stress the load-carrying capacity of the 1200. Tracking error in right ascension was a superb 10 arcseconds over a five-minute period. This is a mount that can just about be left to track by itself during astrophotography.

As with the other Astro-Physics mounts, there was some backlash in declination, making it tricky to perform fine adjustments to the position of a guidestar in declination when guiding at high power.

If you have your eye on a big refractor or a large-aperture reflector and want a mount built to take it, the 1200 may be for you.

The Joy of Refractors

The current selection of apochromatic refractors on the market is enough to make any lover of fine telescopes drool. The Astro-Physics units I tested proved to be first-class instruments made to exacting standards of performance. Fitted with optional guidescopes, refractors like these have been used to create some of the finest astrophotos ever taken.

The limited production numbers and high demand for Astro-Physics telescopes have produced waits of several months to a year for many models, but if you are looking for some of the finest instruments on the telescope market today, the wait may be worth it. ☐

Exploring the South Polar Sky

Journey with us to the Southern Hemisphere, where you'll meet the biggest and best galaxies, the brightest clusters and nebulae, and starfields galore.

by Deborah Byrd

We in the Northern Hemisphere view the beauty of Southern Hemisphere skies as nothing short of legendary. Some stargazers spend years planning and saving to journey south of the equator. Few who make the trip regret the effort.

That's because Southern Hemisphere skies offer many of the grandest sights visible from anywhere on Earth. There are the Large and Small Magellanic Clouds, two nearby galaxies that appear bigger and brighter than any other galaxies in the sky. There's Omega Centauri, a cluster of a million stars that's easy to see with the naked eye. There's the Southern Cross, a group of four bright stars, which looks more like its namesake than any other constellation in the sky. And much more.

Despite its riches, the southern sky lacks an anchor that we in the Northern Hemisphere take for granted: There is no bright star anywhere near the sky's south pole. Instead, the unspectacular constellation Octans the Octant occupies the imaginary point in the heavens where Earth's axis, if you could extend it into space, would touch the sky. The star Sigma Octantis lies about a degree from this point. It is as close as any star currently comes to being the southern "Polaris," but at magnitude 5.5 it is barely visible to the naked eye. Even without a bright star to guide you, it's not impossible to locate the south celestial pole. Read on, and

CENTAURUS, CRUX, CARINA, AND BEYOND. You don't need a telescope to relish the rich southern constellations.

Terence Dickinson

you'll discover two ways to do it.

But first, let's find our own anchor for this region of the heavens. A good one on September evenings is Achernar, which for an observer at 40° south latitude lies about halfway up in the southeast at midevening. Achernar, whose name comes from an Arabic phrase meaning "the end of the river," marks the southern tip of the winding constellation Eridanus the River. At magnitude 0.5, it is the brightest star in this part of the sky. Achernar is circumpolar from a latitude of 40° south, meaning it never dips below the horizon but instead circles endlessly around the south celestial pole. In our tour of the southern sky, we'll visit all the constellations that appear circumpolar as seen from about 40° south.

Once you've found Achernar, shift your gaze up and to the west as though you were following the hands of an imaginary clock. You'll see another noticeable star, though it's not nearly as bright as Achernar. This is 1.9-magnitude Alpha Pavonis, the brightest star in the dim constellation Pavo the Peacock. This constellation honors the bird that was sacred to Juno, the mythological queen of the gods, although Pavo was not named until the 17th century.

Following the clock hands around toward the southwest, you'll come to a group of three stars forming an isosceles triangle. This is Triangulum Australe the Southern Triangle. Alpha Trianguli Australis, or Atria, is a 1.9-magnitude reddish-orange giant located just over 100 light-years from Earth. The constellation's second brightest star, Beta, is a 2.9-magnitude white star 33 light-years distant. The third star in the triangle is Gamma, a white main-sequence star shining at magnitude 2.9. It is slightly closer to Earth than Alpha, lying 90 light-years away.

By now you can't help but notice two bright stars nearby. In midevening at this time of year, they lie fairly low in the southwest, and yet they still appear conspicuous. They are Alpha (α) and Beta (β) Centauri, the two brightest stars in the constellation Centaurus the Centaur, which lies in the midst of a rich region of the southern Milky Way.

Alpha Centauri represents the foot of the half-man, half-horse centaur. Shining at magnitude –0.3, it ranks as the third-brightest star in the entire sky. Alpha is bright largely because it is so near us — at a distance of 4.3 light-years, or about 25 trillion miles, it is the second-closest star to the Sun. It is a star much like our star, but unlike the Sun, the single point of light we see as Alpha Centauri is really two stars. A small telescope splits the pair easily; currently the stars lie 18" apart. About 2° from this pair lies a third star, an 11th-magnitude red dwarf that is a hundred times too faint to see with the naked eye. This is Proxima Centauri, whose name reflects the fact that it is our Sun's closest neighbor at just 4.2 light-years away. Astronomers long considered Proxima to be an outlying member of the Alpha Centauri system, but recent studies of the stars' motions have cast some doubt on that conclusion.

Beta Centauri has the proper name Hadar. It shines at magnitude 0.6 and represents the knee of the centaur. Beta is a blue giant star and, though it appears only slightly dimmer than Alpha, lies more than 100 times farther away at a distance of 460 light-years. Alpha and Beta make Centaurus the only constellation besides Orion to contain two 1st-magnitude or brighter stars.

Don't leave Centaurus behind without locating Omega (ω) Centauri — the brightest globular cluster in the sky. At a distance of 17,000 light-years, it is one of the most remote objects in our Galaxy you can see with the naked eye. Although the name Omega typically designates a star, binoculars reveal this object to be a large, fuzzy patch. A telescope resolves the object into some of its million stars, which are among the oldest in the Galaxy.

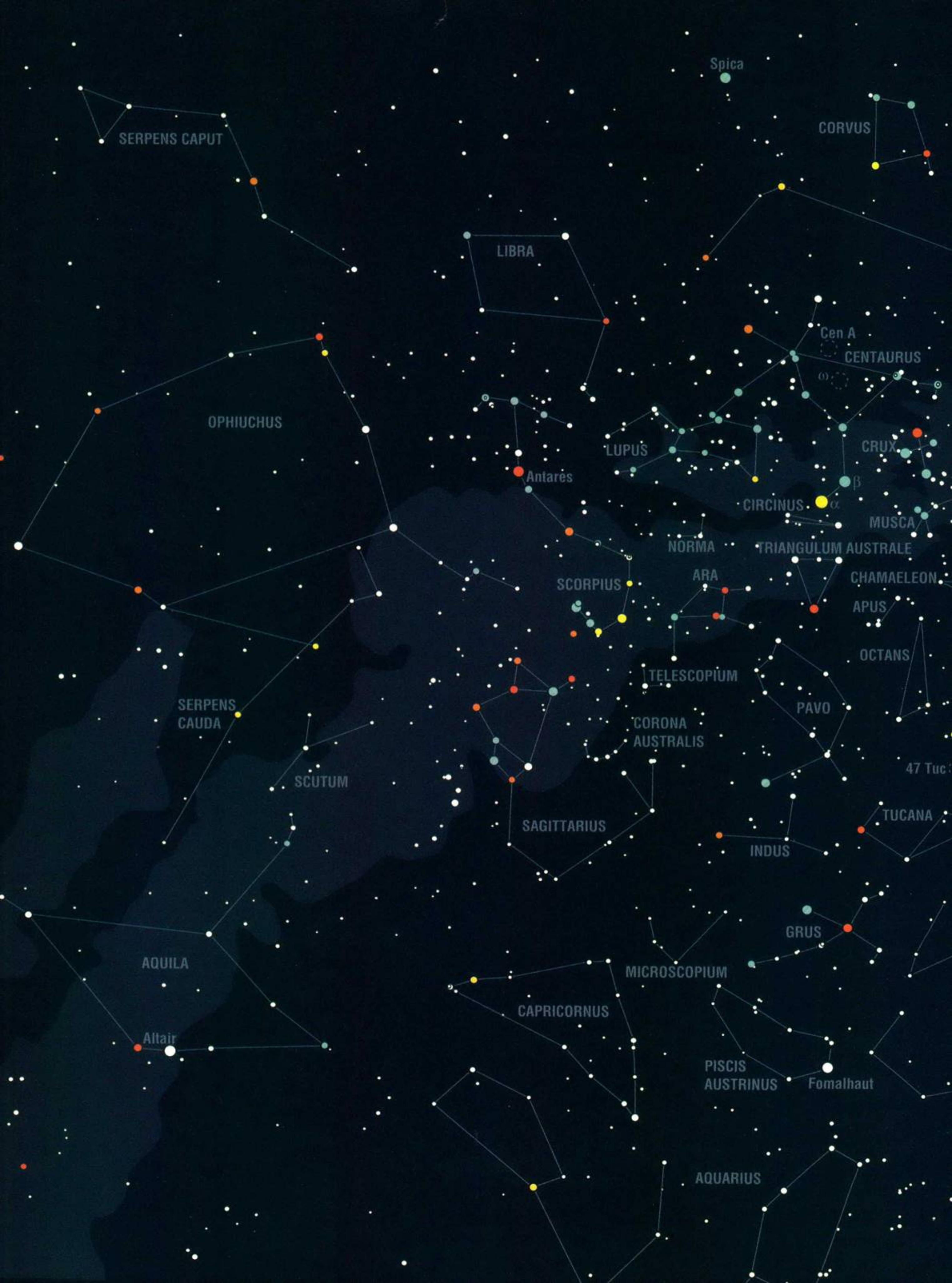
Chris Floyd

THE RUDDY GLOW surrounding Eta Carinae is the most spectacular emission nebula in the sky.

Now draw a line from Alpha to Beta Centauri and continue it toward the southwestern horizon. Low in the sky on these Southern Hemisphere spring evenings, you will find one of the most famous of all star patterns, Crux the Southern Cross. (It, like most other constellations in the southern Milky Way, appears highest in the evening during the Southern Hemisphere's autumn, which runs from March to May.) Although Crux is the smallest of the 88 constellations, the striking shape of its four brightest stars and its location among the rich starfields of the southern Milky Way embody the wonder of the southern skies to stargazers north of the equator.

Alpha Crucis, or Acrux, marks one end of the Cross' long axis. It is the 14th-brightest star in the sky, a brilliant double that lies about 400 light-years away. Marking the other end of the Cross' long axis is Gamma Crucis, or Gacrux, a 1.6-magnitude red giant star. Does this star appear red to your naked eye? If not, try to detect its color with binoculars.

Beta and Delta Crucis form the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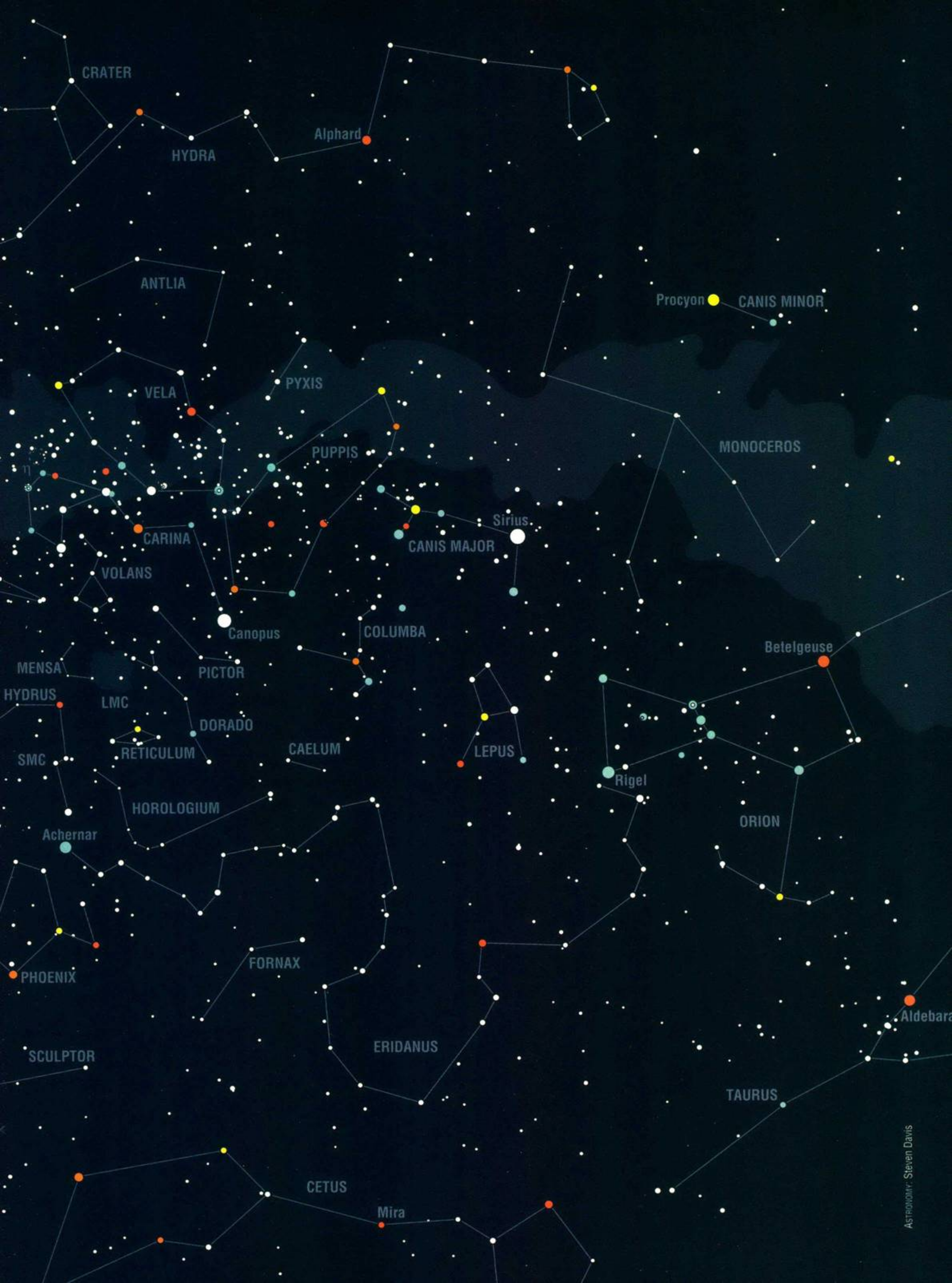
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ASTRONOMY: Steven Davis

Jim Barclay

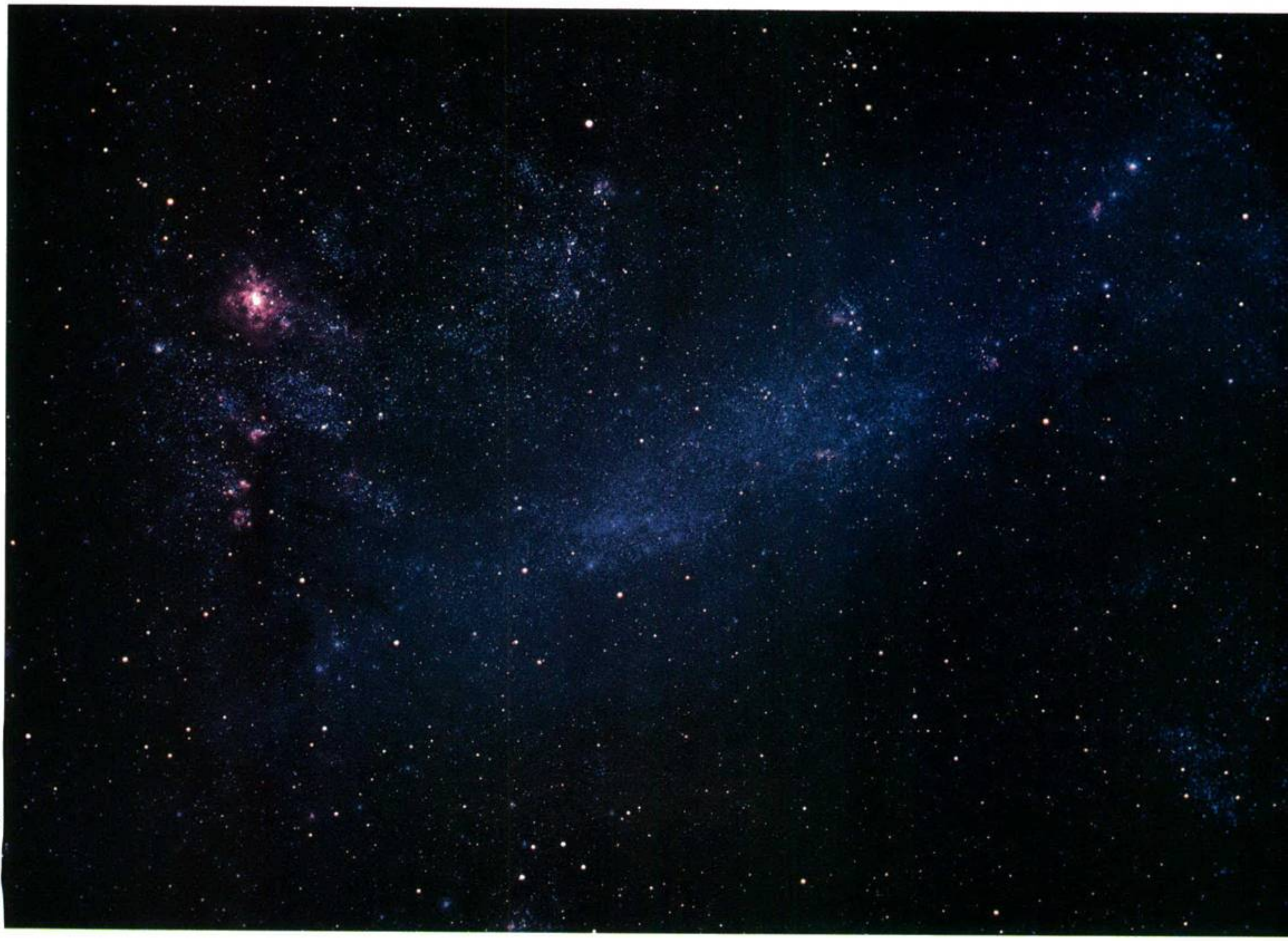
A MILLION STARS pack into the globular star cluster known as Omega Centauri — the biggest and brightest globular visible from anywhere on Earth.

short axis of the Cross. Beta is a blue giant star that shines at magnitude 1.3. Delta shines at magnitude 2.8, making it the dimmest of Crux's four main stars.

Between Alpha and Beta Crucis, you'll find a strange spot in the heavens, an apparent hole in the tapestry of the stars. This is the Coal Sack, a dark cloud of dust that hides the light of stars shining behind it.

Now you're ready to try to locate the south celestial pole. For the first technique, point one arm to Beta

THE MILKY GLOW of the Large Magellanic Cloud, the largest and brightest of the Milky Way's satellite galaxies, is highlighted by the immense Tarantula Nebula, the ruddy region at upper left.


ASTRONOMY: Alan Dyer

Centauri and the other to Achernar and then slowly bring your arms together. When they meet they'll be pointing near the sky's south pole. You can also find the position of the pole by extending the long axis of the Southern Cross by 4 1/2 times its length beyond Alpha Crucis.

From Crux let's now head back counterclockwise to pick up some of the smaller, less noticeable constellations in the south circumpolar sky. Chamaeleon the Chameleon contains no star brighter than 4th magnitude. Yet star atlases sometimes show mighty Chamaeleon poised to descend on little Musca the Fly, which buzzes between Chamaeleon and Crux. The most conspicuous stars in Musca are Alpha Muscae, which shines at magnitude 2.7, and Beta Muscae, a 3.1-magnitude double star that lies a little over a degree from Alpha.

Continuing counterclockwise around the pole, you'll find Circinus the Compasses just above Alpha and Beta Centauri. Circinus contains one reasonably bright star, a 3rd-magnitude, whitish double called Alpha Circini.

Now look between Triangulum Australe and Octans for a small, faint constellation with a lovely name — Apus the Bird of Paradise. It contains three stars that shine at 4th magnitude. Then shift from Apus — across Triangulum Australe — to find the box-shaped Ara the Altar. Beta Arae is its brightest star at magnitude 2.9.

As you keep moving counterclockwise, past Pavo, you'll find still more small and dim (but charmingly named) constellations. Tucana the Toucan boasts one 3rd-magnitude star. But the two most famous objects within this constellation's boundaries are not stars at all.

The first is 47 Tucanae, a globular star cluster containing hundreds of thousands of stars. This symmetrical collection is the second-brightest globular in the sky, behind only Omega Centauri. You'll need a small telescope to resolve the cluster's faint outer stars and see the strong yellow color of the cluster's core.

The second dwarfs even 47 Tucanae. It is the Small Magellanic Cloud, one of the Milky Way's two bright satellite galaxies, which can be seen only from the Southern Hemisphere. The SMC contains literally billions of stars as well as its own collection of clusters and nebulae. Be sure to sweep this area with binoculars or a telescope.

Between Tucana and the south celestial pole, you'll find Hydrus the Lesser Water Snake. It is relatively inconspicuous, containing three 3rd-magnitude stars. And there are more: Reticulum the Net, Horologium the Clock, Dorado the Swordfish, Mensa the Table Mountain, and Volans the Flying Fish all occupy the southern part of the sky.

Amongst these inconspicuous constellations lies a nebulous patch that looks like a detached piece of the Milky Way. But this is far from an ordinary nebula in the Milky Way. It is the Large Magellanic Cloud, a galaxy of tens of billions of stars that is not only the nearest galaxy to our own but also the one that appears largest and brightest.

You could spend an entire night just exploring the LMC. With binoculars or a telescope, you can view dozens of clusters and emission nebulae. The most stunning object in the LMC is the Tarantula Nebula, an emission nebula visible to the naked eye despite lying 170,000 light-years away. If the Tarantula were as far away as the Orion Nebula — a couple of thousand light-years — it would cover 30° of sky and appear several times brighter than Venus.

After midnight, the constellation Carina the Keel ascends in the southeast. Carina was once a part of Argo Navis, an ancient constellation representing the great ship of Jason and the Argonauts. Argo Navis sailed the southern skies until Nicolas Louis de Lacaille decided to chop it into pieces in the 18th century. Carina contains the sky's second-brightest star, Canopus. This star shines at magnitude –0.7 across a distance of 71 light-years. Of all the stars, only Sirius outshines Canopus.

Jack Marling

THE PECULIAR GALAXY CENTAURUS A glows with the light of hundreds of billions of stars, but a dark dust lane hides the galaxy's center.

Carina also holds a spectacular emission nebula visible as a fuzzy patch to the naked eye. Surrounding the star Eta (η), the Eta Carinae Nebula is the brightest such object in the sky, surpassing the Orion Nebula. (In absolute terms, however, the Tarantula Nebula in the LMC is still tops.)

The constellation Vela the Sails, another part of the old Argo Navis, follows Carina into the southeastern sky. Vela lies in a rich region of the Milky Way. Its brightest star is Gamma Velorum, which shines at magnitude 1.8. Gamma ranks as one of the hottest stars in the Galaxy, with a surface temperature of over 30,000 kelvins.

Vela and Carina complete our circuit of the south circumpolar sky, returning us to Crux and Centaurus. For those of us who live in the Northern Hemisphere, it's a region of exotic riches that beckons us to the other side of the globe. But we suspect that even if you live south of the equator, you will never grow tired of the glorious south polar sky. ☐

Deborah Byrd writes ASTRONOMY's monthly sky column for naked-eye observers, "Eye on the Sky." This is the last of her six articles highlighting all the sky's constellations.

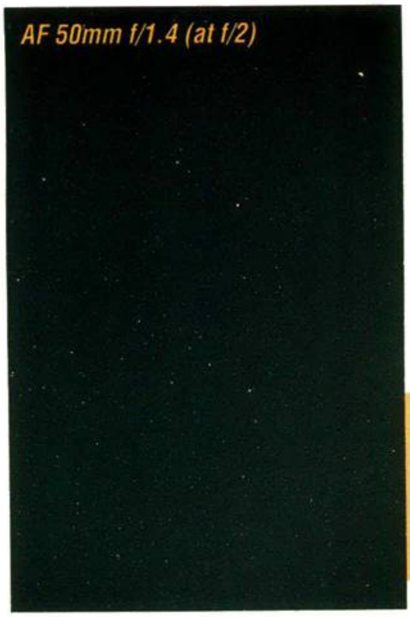
SEEKING THE BEST 35MM CAMERA

ASTRONOMY goes in search of an increasingly rare creature — a non-electronic manual camera ideal for astrophotography. And guess what? We found several!

by Alan Dyer

PENTAX
F-1
Canon
PENTAX
K1000
CONTAX

IN A ROUNDUP OF RARE SPECIES ASTRONOMY tested manual 35mm cameras ideal for taking long-exposure astrophotos, such as Terence Dickinson's portrait of Cygnus. He used a Canon F-1 camera and Canon 85mm f/1.2 lens (set to f/1.7) on Scotchchrome 400 film pushed to ISO 800.


AF 50mm f/1.4 (at f/2)

AF-ED 180mm f/2.8

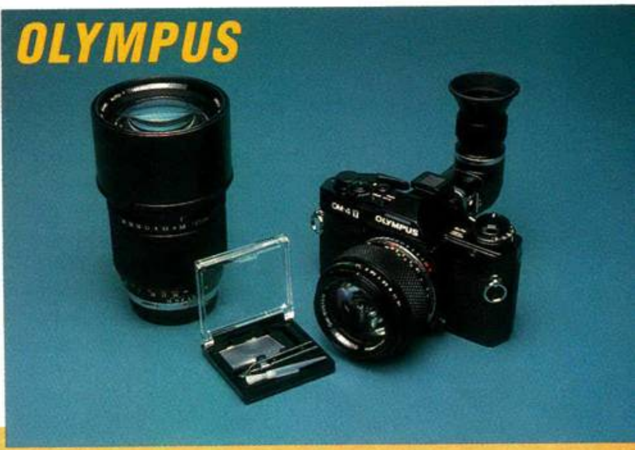
NIKON

THE NIKON 50mm f/1.4 lens ($322) showed moderate coma at f/2 and vignetting slightly worse (more) than average. The Nikon 180mm f/2.8 ED lens ($970) gave uniform star images edge-to-edge and showed no chromatic aberration. Both lenses were difficult to focus precisely at infinity.

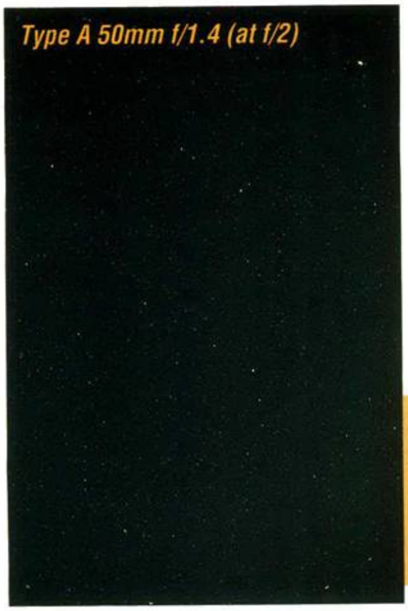
Zuiko 50mm f/1.2 (at f/2)

Zuiko 180mm f/2.8

OLYMPUS



THE OLYMPUS Zuiko 50mm f/1.2 lens ($457) showed moderate coma at f/2 and vignetting slighty better (less) than average. The Zuiko 180mm f/2.8 lens ($1,320) showed noticeable chromatic aberration and some coma in blue light on stars near the corners of the frame.


Type A 50mm f/1.4 (at f/2)

ED 200mm f/2.8

PENTAX

PENTAX
PENTAX

THE PENTAX Type A 50mm f/1.4 lens ($280) showed moderate coma at f/2 and an average level of vignetting. The Pentax 200mm f/2.8 ED lens ($1,497) gave sharp star images edge-to-edge and showed no chromatic aberration, a benefit of the ED glass now used on many telephoto lenses.

FEATURING INTERCHANGEABLE FOCUSING SCREENS, the Nikon FM2 and Olympus OM-4T are popular cameras for astrophotography. Their screens are inserted through the lens mounts. You can attach optional right-angle finders or straight-through magnifiers to the viewfinder eyepieces for critical focusing.

several models of cameras. (Intenscreens are not available for Canon cameras, but Canon's own laser-matte Type K screens are similar.)

The fine matte screens are best for deep-sky photography. For high-magnification lunar and planetary shots, a focusing screen with a clear central spot is useful — it provides a very bright image to focus on. Clear spot screens are available for several cameras in the group.

Another useful feature is an interchangeable finder. Only the Canon F-1, Nikon F3, and Pentax LX offer this feature. Their optional magnifier finders provide the brightest images possible, making framing an object easy and focusing very precise. The right-angle viewing these finders provide makes it comfortable to look through these cameras when they are attached to a Schmidt-Cassegrain or refractor telescope. The finders and bright viewfinder images of these three cameras make them the top choices, although the most expensive.

Some cameras without interchangeable finders (such as the Olympus OM-4T and Nikon FM2) have right-angle viewing attachments that clip onto the normal viewfinder. (We checked the Olympus Varimagni Finder and the Nikon DR-3 finders.) These work fine but produce dimmer images than cameras with interchangeable finders do. Dimmer images make it more difficult to see faint objects through the camera. The Nikon FM2 also has a straight-through clip-on magnifier, the DG-2. It helps in critical focusing but shows only the center of the frame.

Quiet Shutters

Another worthwhile feature is a mirror lockup. When shooting the Moon, shutter speeds usually fall in the 1/500- to 1/2-second range. The slap from the mirror as it swings up just prior to the shutter's opening can introduce image-blurring vibration. Locking the mirror up beforehand greatly reduces the level of vibration and makes for a sharper photo.

Not all cameras have this feature. Some top-end models such as the Canon F-1 lack a mirror lockup. The economical Pentax K1000 has an "unofficial" mirror lockup not mentioned in the manual — cock the shutter and then lightly tap the shutter release button. Voilá! The mirror locks up! You can then fire the shutter. The mirror comes down when the shutter closes.

A quiet, vibration-free shutter is also a plus. The Nikon F3 and Olympus OM-4T had the gentlest shutter mechanisms. The Pentax K1000 was also very quiet and vibration free, a surprising trait for such a low-cost camera.

Some cameras have frame advance levers that can be cocked by a single stroke or with several short strokes. This "ratchet winding" can be useful for advancing the film without jarring the telescope.

All the cameras on our list have built-in light meters, which are useful for photos of sunsets, the planets in the twilight sky, and daytime subjects. But for shots through a telescope there is little need for a light meter, let alone any type of automatic exposure control. Instead, exposures for telescopic shots are almost always determined from tables or from experience.

Nevertheless, if your choice is going to perform double duty as a general purpose camera, you may want to select a model with auto ex-

THE MOST VERSATILE CAMERAS such as the Pentax LX, Canon F-1, and Nikon F3 offer both interchangeable focusing screens and interchangeable finders. These high-end models are shown with their optional 6x magnifier finders, recommended accessories for astrophotography.

Astrophoto Cameras at a Glance

35mm camera	Non-battery speeds	Slowest shutter speed	Changeable focusing screens	Fine matte screen	Clear spot screen	Changeable finder	Mirror lockup	Ratchet winding	Exposure control	Weight (body only w/finder)	Sugg. List (body only w/standard finder)*
Canon F-1	1/90 to 1/2000 + B	8 sec.	yes	Type K	Type I	yes	no	yes	Auto	795 g (28 oz)	$2,100
Contax S2	1 to 1/4000 + B	1 sec.	yes	FU-5	NA	no	no	no	Manual	565 g (20 oz)	$999
Leica R6.2	1 to 1/2000 + B	1 sec.	yes	#14304	#14307	no	yes	?	Manual	625 g (23 oz)	$3,675
Nikon FM2	1 to 1/4000 + B	1 sec.	yes	Type B2	NA	no	no	no	Manual	540 g (19 oz)	$605
Nikon F3	1/60 + B	8 sec.	yes	Type D	Type C	yes	yes	yes	Auto	760 g (27 oz)	$1,400
Olympus OM-4T	1/60 + B	1 sec.	yes	#1-8	#1-11	no	no	yes	Auto	510 g (18 oz)	$1,300
Pentax K1000	1 to 1/1000 + B	1 sec.	no	NA	NA	no	yes (see text)	yes	Manual	525 g (19 oz)	$245
Pentax LX	1/75 to 1/2000 + B	4 sec.	yes	SE-25	SD-21	yes	yes	yes	Auto	570 g (20 oz)	$1,977

*The prices are for the camera body and standard pentaprism finder only. Lenses are extra. The prices are suggested list as of mid-1993; actual retail prices will be lower through most camera stores and mail-order houses.

NA = not available

posure capability. The Canon F-1, Nikon F3, Olympus OM-4T, and Pentax LX have aperture-priority auto settings — you set the lens aperture and the camera will select the shutter speed for you.

Weight is another consideration. Lightweight cameras are easier to balance on a telescope and are a better match for small telescopes on lightweight mounts. Of the cameras on our list, the Olympus OM-4T and Pentax K1000 are the lightest of the bunch.

Buying Used

If you are on a budget, an excellent alternative is to purchase a used camera body and perhaps used lenses to match. There is a thriving market for second-hand cameras. Buyers are snapping up both current and discontinued mechanical shutter models as fast as other people are trading them in when they switch to new electronic cameras.

You'll find used cameras in your local camera store and through mail-order camera dealers. Prices are much lower than those on new models, and by shopping around you can get even 20-year-old cameras and lenses in surprisingly good condition.

Some of the best discontinued models to look for suitable for astrophotography are the original Canon F-1 (it had a mirror lockup), the Nikon F and F2, and Olympus OM-1. But watch out — with some brands the manufacturer's new lenses and accessories won't fit the old camera bodies. For example, autofocus lenses for Canon's EOS series of cameras will not fit on their current or older model F-1 cameras. The F-1 requires the FD series of manual focus Canon lenses.

With Nikon, all their lenses, old and new, will fit and focus on every 35mm camera Nikon has ever made. However, some of their old lenses won't connect to the light meters in the new Nikon bodies, and vice versa. Focusing screens and finders for the new Nikons won't fit on the old Nikon F and F2 bodies. With Olympus, lenses and focusing screens for the OM-4T are all compatible with the original OM-1. New Pentax lenses will fit all their older K-mount cameras.

Not Extinct but Endangered?

While it's easy to bemoan the current crop of automatic cameras and their unsuitability for astrophotography, the fact is, a very good selection of new cameras is available with all the requisite features. The question is, how much longer will these manual, mechanical cameras survive in the world of electronic marvels? Some, like the venerable Pentax K1000, seem to go on forever. Others could be discontinued at any time, putting them on the endangered species list.

Nevertheless, most manufacturers and dealers have realized there is a market for the no-frills reliability of a mechanical camera. Whether new or used, these workhorses will be around for some time. ☐

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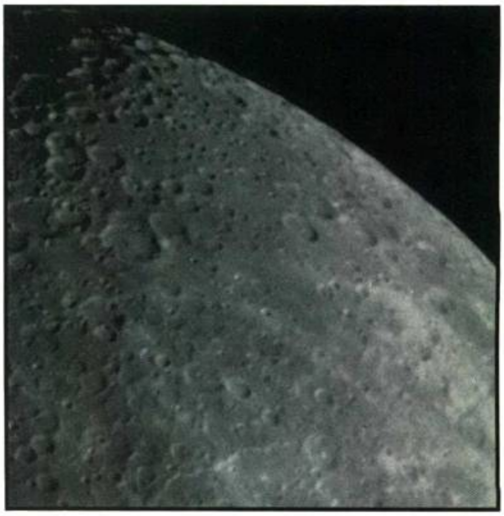


Lunar Terminator. *Single 0.4 second CCD image taken at the prime focus of a C-11 apertured down to 2.5 inches. Courtesy SBIG.*

TAKING THE PLUTO CHALLENGE

Armed with a 16-inch f/4.5 reflector and an SBIG ST-4 CCD camera, members of the Santa Monica College Astronomy Club accepted the Pluto challenge. (See "Pluto Watch," May 1993).

On April 19, 1993, Gary A. Fouts, the club's faculty adviser, first imaged the elusive solar system target. Club vice president Alan Bishop succeeded in recording Pluto the following night. On the 21st Erich de Leon and Laurie McElhannon attempted further exposures but were stopped by high winds.

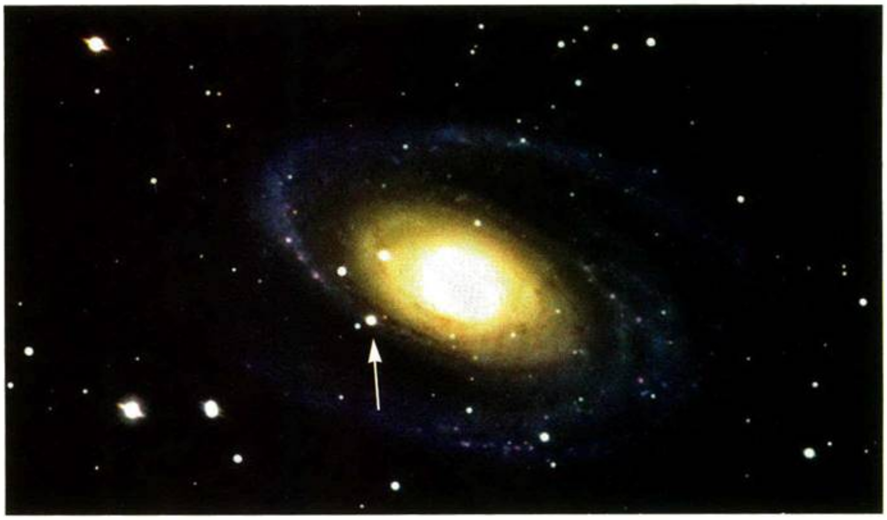
All of the club's CCD exposures were processed using Richard Berry's AstroIP software. "Patchy cirrus and wind vibration were obstacles," says Fouts, "but the club nevertheless captured the distant planet for later enjoyment."

Major Solar Flare Explodes. A major solar flare erupted at 11:48 a.m. EST on March 12, 1993. The flare surrounded a sunspot group near the Sun's western limb and reached maximum brightness by about 1:20 p.m. By 3:42 p.m. the flare had subsided and was no longer visible.

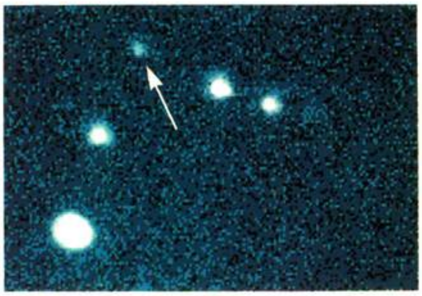
Don Trombino of the Davis Memorial Solar Observatory in Deltona, Florida, captured the flare using his 6-inch refractor fitted with a DayStar hydrogen-alpha filter. "I also tried to determine whether the event was visible in white light by observing its broadband emission in blue light using a 3-inch refractor with a Herschel wedge and a Wratten #47 deep blue filter. Although I didn't see the large flare in white light, I did detect a brightening around the sunspot." Did other readers observe this event?

Venus Occulted by the Moon. On April 19 the Moon occulted Venus for observers in most of North America. Members of the Northeast Florida Astronomical Society observed the noontime spectacle. "Early in the morning the predawn sky was clear and the Moon and Venus shone brightly about 3° apart," says Roger Curry. Eight society members met around 11:30 a.m. and prepared to record their observations of the occultation. After setting up telescopes and offsetting from the Sun, the observers found the Moon and Venus in a low-power field of view.

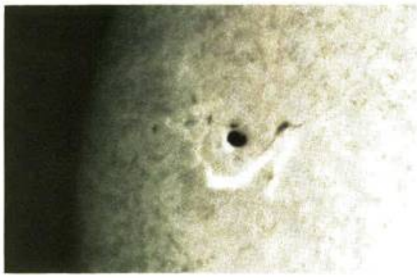
"Venus was a bright, thin crescent and the Moon appeared similarly shaped but was barely brighter than the sky background itself," says club vice president Stephen Meeks. "As the Moon closed in on Venus, each observer glanced through Roger's telescope until we finally saw the last light of Venus slip away at 12:09 p.m."



SUPERNOVA 1993J (arrow) in the spiral galaxy M81 faded during April and May 1993 but remained bright enough to see in a small telescope. Photo taken on April 25 by Bill and Sally Fletcher.



ELUSIVE PLUTO (arrow) showed up on a CCD image (right) taken on April 19 by Gary A. Fouts and his students at Santa Monica College in California.

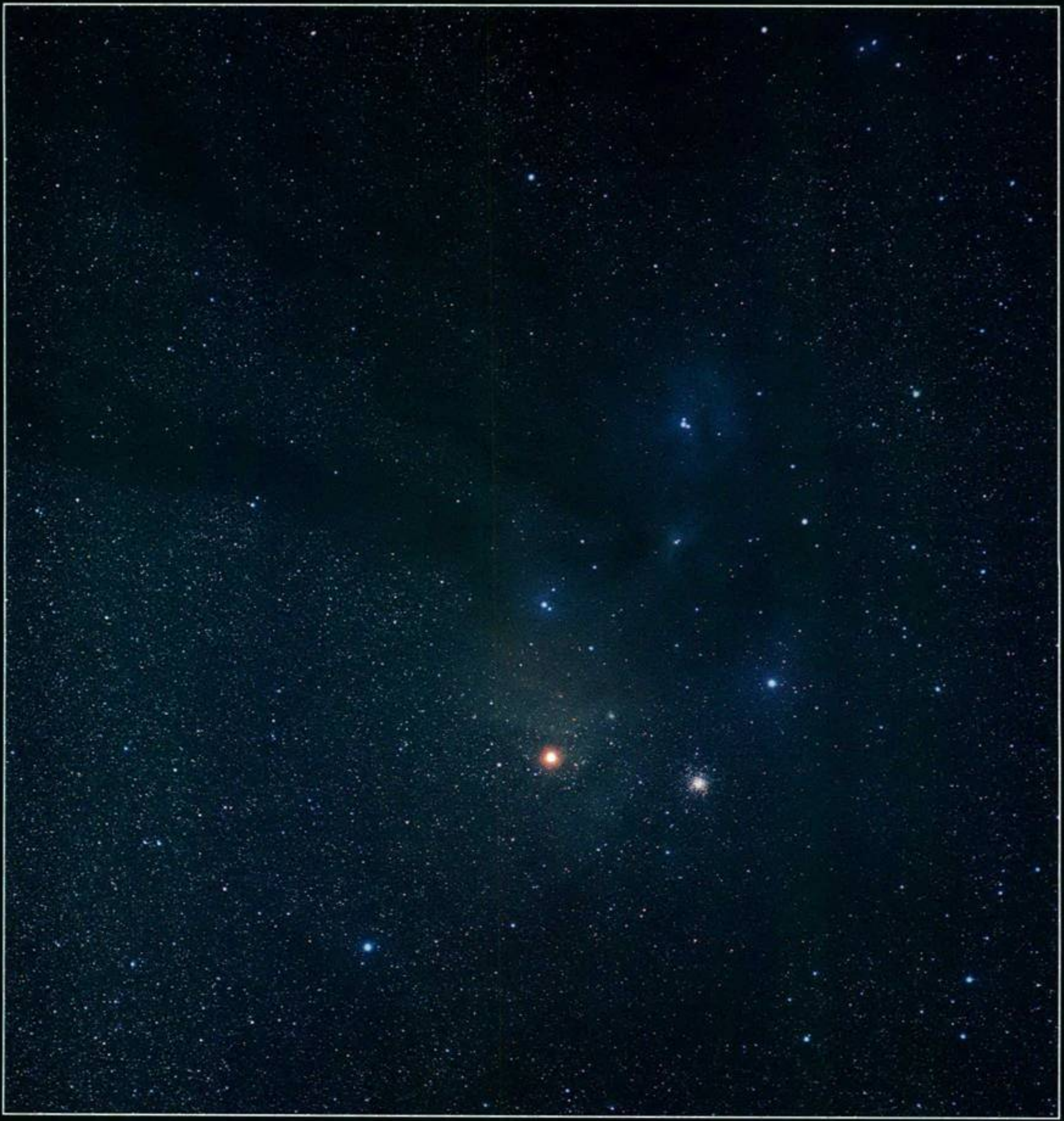


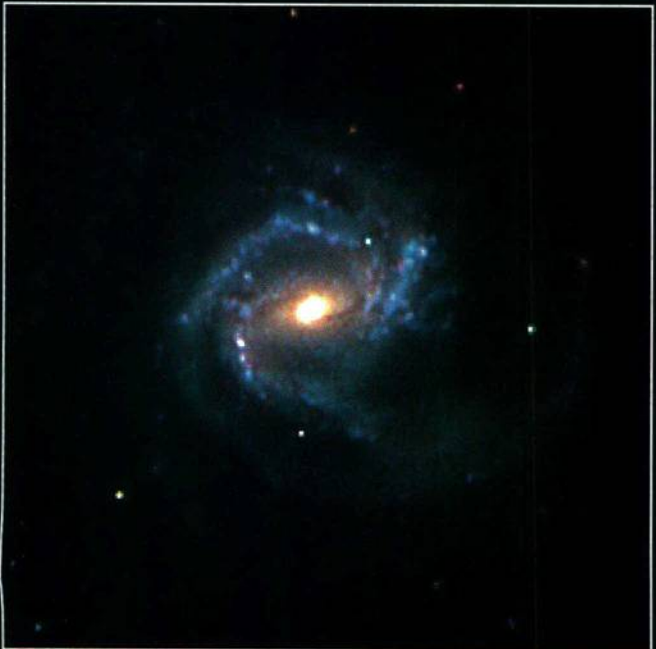
A BRIGHT SOLAR FLARE occurred on March 12 (below right) and was captured by Floridian Don Trombino using a 6-inch refractor and a hydrogen-alpha filter.

Supernova in M81. One of the highlights of springtime observing in 1993 was the bright supernova in the spiral galaxy M81. "On March 30 my observing friend George Kelly of Glade Spring, Virginia, told me of the supernova's existence," says Gus E. Johnson of Swanton, Maryland. Johnson himself discovered a supernova in M100 in 1979. "The evening was clear," he continues, "so I soon had the object in view in my 6-inch reflector. I thought the star glowed at about magnitude 10.4, but five hours later I re-observed the star and it seemed about 0.2 magnitude brighter.

"Despite the six-day-old Moon in the sky," Johnson remarks, "I could still see the supernova with my telescope's aperture reduced to 2.4 inches." ☐

ASTRONOMY wants to hear about your observations of the sky. Please send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187.





LOOKS LIKE A MILLION

"Hey, you look like a million."

Well, globular star cluster M22 in Sagittarius really *does* look like a million. The cluster, which orbits far out in the Milky Way's halo, holds a million stars in its gravitational grip. Gary Jones and Mike Warnell photographed the cluster (opposite page, top) and earned this month's $100 "Best Astrophoto" award.

Canadian astro-imager Jack Newton captured the subtle colors of galaxy M61 in Virgo with his 25-inch reflector and an SBIG ST-6 CCD camera (left).

Hues of rose, amber, and blue stain the region of Rho Ophiuchi, which includes the bright star Antares and the globular star cluster M4 (above). Luke Dodd photographed the area using a 300mm lens.

Much closer to home, Bill and Sally Fletcher recorded a rainbow of color in a cloud release experiment in California (opposite page, bottom). On March 9 a Minuteman III rocket launched from Vandenberg Air Force Base produced this spectacular sight. Venus lies to the upper left of the cloud.

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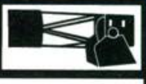

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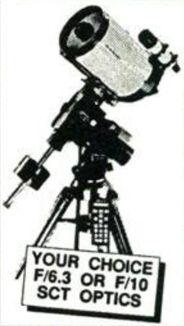

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Star Diagonal 1¼" w/Multicoatings	**39**		
Star Diagonal .96"	**21.95**	Tele Extender	**29.95**
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GLASS - *TYPE 1* *(Full Aperture)*

Made from high quality hand select glass, machine polished and TRIPLE COATED with a Nickel-Chromium alloy (same as Inconel). Mounted in a machined aluminum cell ready to attach to telescope. Solar image is yellow-orange. No secondary filtering is necessary.

Aperture	Mounted	Aperture	Unmounted
2.4"	$49.00	2.4"	$39.00
3.1"	52.00	3.1"	42.00
3.5" to 4"	59.00	3.5 to 4"	49.00
4-1/4" to 5"	74.00	4-1/4" to 5"	64.00
6"	79.00	6"	69.00
8"	95.00	8"	85.00
10"	109.00	10"	99.00
11"	119.00	11"	109.00
12.5" to 13.1"	149.00	12.5" to 13.1"	129.00
14"	169.00	14"	149.00

40mm to 80mm Binoculars - Mounted .... $92.00 pr.

GLASS - *TYPE 2* *(Full Aperture)*

Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
4-1/4" to 5"	96.00	4-1/4" to 5"	86.00
6"	105.00	6"	95.00
8"	125.00	8"	109.00
10"	139.00	10"	119.00
11"	149.00	11"	139.00
12.5" to 13.1"	179.00	12.5" to 13.1"	159.00
14"	199.00	14"	179.00

40mm to 80mm Binoculars - Mounted .... $115.00 pr.

GLASS - *TYPE 3* *(Full Aperture)*

Coated to a neutral density of 4 for serious astrophotographers who desire the shortest possible shutter speeds with slow films. Solar image and optical quality same as type 1 & type 2. Type 3 filters are for photographic use only.

Aperture	Mounted	Aperture	Unmounted
2.4"	$79.00	2.4"	$65.00
3.1"	82.00	3.1"	69.00
3.5" to 4"	99.00	3.5 to 4"	79.00
4-1/4" to 5"	125.00	4-1/4" to 5"	110.00
6"	135.00	6"	115.00
8"	159.00	8"	139.00
10"	172.00	10"	152.00
11"	199.00	11"	179.00
12.5" to 13.1"	229.00	12.5" to 13.1"	209.00
14"	259.00	14"	239.00

Threaded camera filters also available.

Types 1 & 2 are for unlimited visual use and general photographic use. Instructions included with all filters, including tips on solar photography.

Our glass filters are more durable than ANY Mylar filters on the market. If you're looking for the most economical filter, we now offer the same type of Mylar filters sold elsewhere, and our prices are reasonably lower. Unlike the competition, we charge the same price for each aperture regardless of brand. We don't charge more if you have an expensive refractor or Maksutov. Sample pricing: C-90 or 2045 - $42.00, C-8 or 2080 - $79.00. Unmounted Mylar is also available.

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3" x 5" Overall size .... $1.00 ea.

Plastic: Same as Mylar except this filter yields a sharper image with orange transmission

2-5/8" x 4-5/8" Overall size .... $2.00 ea.

Minimum order of 10 eclipse filters in any combination. Please add appropriate shipping/handling. 10 units: $3.00. Plus $1.00 for each additional 10 units. Minimum credit card order of $25.00. Quantity discounts available starting at 100.

Mylar and plastic viewers are coated to a neutral density of 5. Transmission in visual light is approximately 1/1,000th of one percent. There is no significant transmission in ultraviolet or infrared. Designed for naked eye visual use.

Free brochure available.

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Solar filters are shipped free in continental U.S. when payment is included with order. Shipping extra on credit card orders ($3-$6 depending on aperture). Payment may be made by personal check, bank check or money order. We also accept **Visa, MasterCard** and **American Express. PLEASE SPECIFY TELESCOPE BRAND AND/OR OUTSIDE DIAMETER MEASUREMENT OF TELESCOPE TUBE.** The cost of the filter is based on the telescope aperture. The mounting cell fits over and around the end of the telescope tube (friction fit). The coating faces the inside. Unmounted filters are the glass only.

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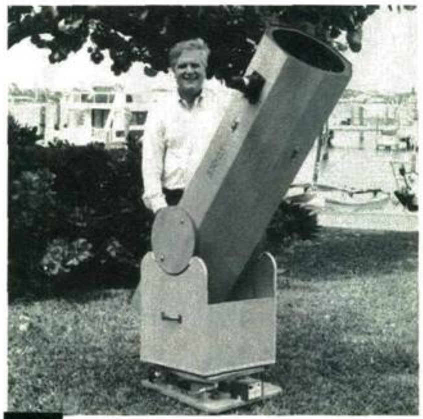
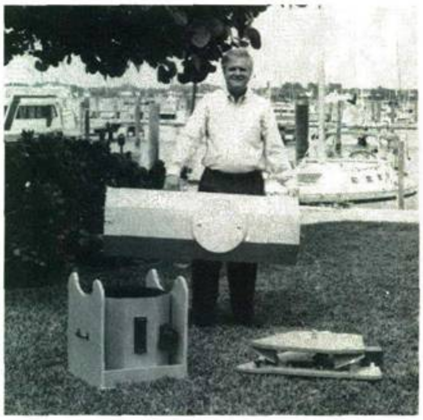




1

Juno 12.5 Equatorial Telescope

Jupiter Telescope Company has introduced a 12.5-inch f/4.5 version of its popular equatorial reflectors. The telescope includes a 22-pound d'Autume platform which forms the base of the telescope. The platform provides up to 70 minutes of equatorial tracking before it needs to be reset. The Juno 12.5 features a hexagonal wooden tube that splits into two sections for easy transport. The heaviest component weighs 38 pounds. Setup time is a claimed three minutes and the eyepiece height is at eye level when aimed at the zenith. The full-thickness Pyrex mirror figured by D&G Optical and Richard Fagin is guaranteed to at least 1/8-wave surface accuracy (1/4-wave at the wavefront). Enhanced mirror coatings are available as an option. Standard fittings include a 9-point mirror cell, a Telrad finder, and a Novak diagonal holder, spider, and 2-inch low-profile focuser.

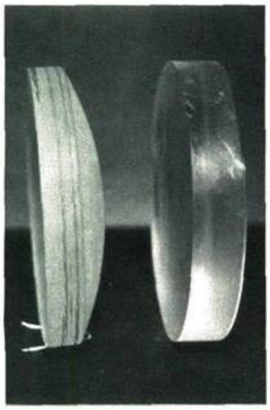
Jupiter Telescope Company, 810 Saturn Street, Suite 16, Jupiter, FL 33477, (407) 694-1154. Introductory price: $2,495.

2

A Long-Focus Refractor

Fraunhofer Systems is offering a 6-inch f/15 refractor tube assembly that incorporates a classic achromatic doublet lens manufactured by Optico Glass Fabrication, Inc. Designed for lunar and planetary observing, this long-focus refractor features an aluminum tube with a push-pull lens cell, 2-inch Unitron focuser, and 8x50 finderscope. An f/10 version is also available for the same price. (Mount shown not included.)

Fraunhofer Systems, 14418 Dickens Street, Suite 6, Sherman Oaks, CA 91423, (818) 986-3601. $2,806 plus shipping and handling.



3

Maksutov Optics Kit

This raw optics set provides the basic components for making a 6-inch f/15 Gregory-Maksutov telescope. The set consists of a 6-inch Pyrex primary blank, a BK7 surface-generated corrector lens blank, and a convex/concave plate-glass tool. The corrector lens blank and finishing tool are matched so that only fine grinding and polishing are required, eliminating hours of rough grinding of the steep corrector lens. The optics set comes with all construction specifications but the user must supply mirror grinding and polishing compounds and other components required for a finished telescope.

TELSTAR, 2130 Primate Road, Mississauga, Ontario, Canada L4Y 1V4, (416) 277-1708. $249.95 (U.S.) plus $10 shipping.

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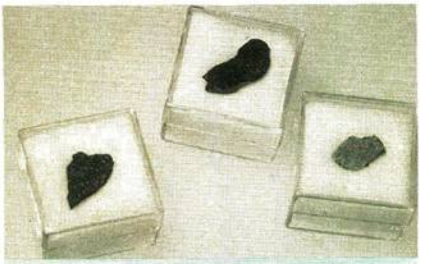
4 Brite Sky Lens Cleaning Solution

Brite Sky cleaning fluid is designed to clean surface residues as well as penetrate to remove oils and other contaminants at the microscopic level on lenses. The manufacturer promises that Brite Sky will improve contrast and light transmission and that the solution is safe for plastics and glass and will not damage optical coatings.

Brite Sky, 5B First Street, Dover, NH, (603) 743-4083. $5.95 for 1¼-ounce bottle.



5 Micro-mount Meteorite Specimens

Bethany Sciences has introduced a collection of micro-mount meteorites. These specimens are designed for collectors and educators who would like to broaden their collections with a variety of specimens at affordable prices. Specimens are protected in clear gemstone boxes and vary in weight and size.

Bethany Sciences, P.O. Box 3726-A2, New Haven, CT 06525-0726, (203) 393-3395. Individual specimens: $10 and up. Write for complete list and color catalog: $2 in the United States, $5 for foreign delivery.

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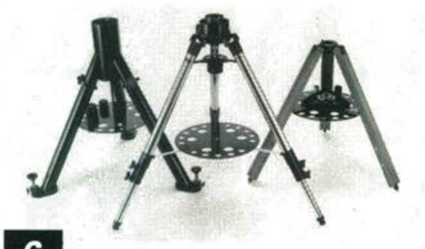
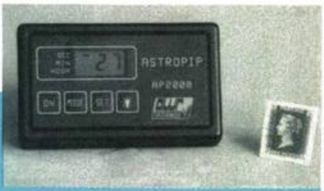


6

Add-on Accessory Tray

This 18-inch-diameter aluminum tray will fit Meade, Polaris, Celestron G-11, and Losmandy GM-100 tripods. It is finished with a high-gloss black powder coating and is large enough to hold large items such as an SBIG Autoguider as well as several 1.25- and 2-inch eyepieces.

DDS Astronomical Products, 240 Belmont Avenue, Long Beach, CA 90803, (310) 433-9745. $79.95 plus $7.95 shipping and handling.



7

ASTROPIP Metronomes

The ASTROPIPs provide a source of accurate time signals that you can hear. Designed for timing astrophotos and astronomical events such as occultations, the metronomes sound a pip at every second and a longer beep every minute. The AP200 provides just audio signals; the AP2000 (shown) also provides a backlit display showing elapsed time in hours, minutes, and seconds. Accuracy for both models is 0.1 second per hour. Batteries are said to last 1,000 hours.

AWR Technology, 67 Thornbridge Road, Deal, Kent, England CT14 9DZ. Phone 44-304-365918. AP200: £29; AP2000: £49.

This department presents new product announcements issued by their manufacturers. The product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers are invited to send their product announcements to the attention of Alan Dyer.

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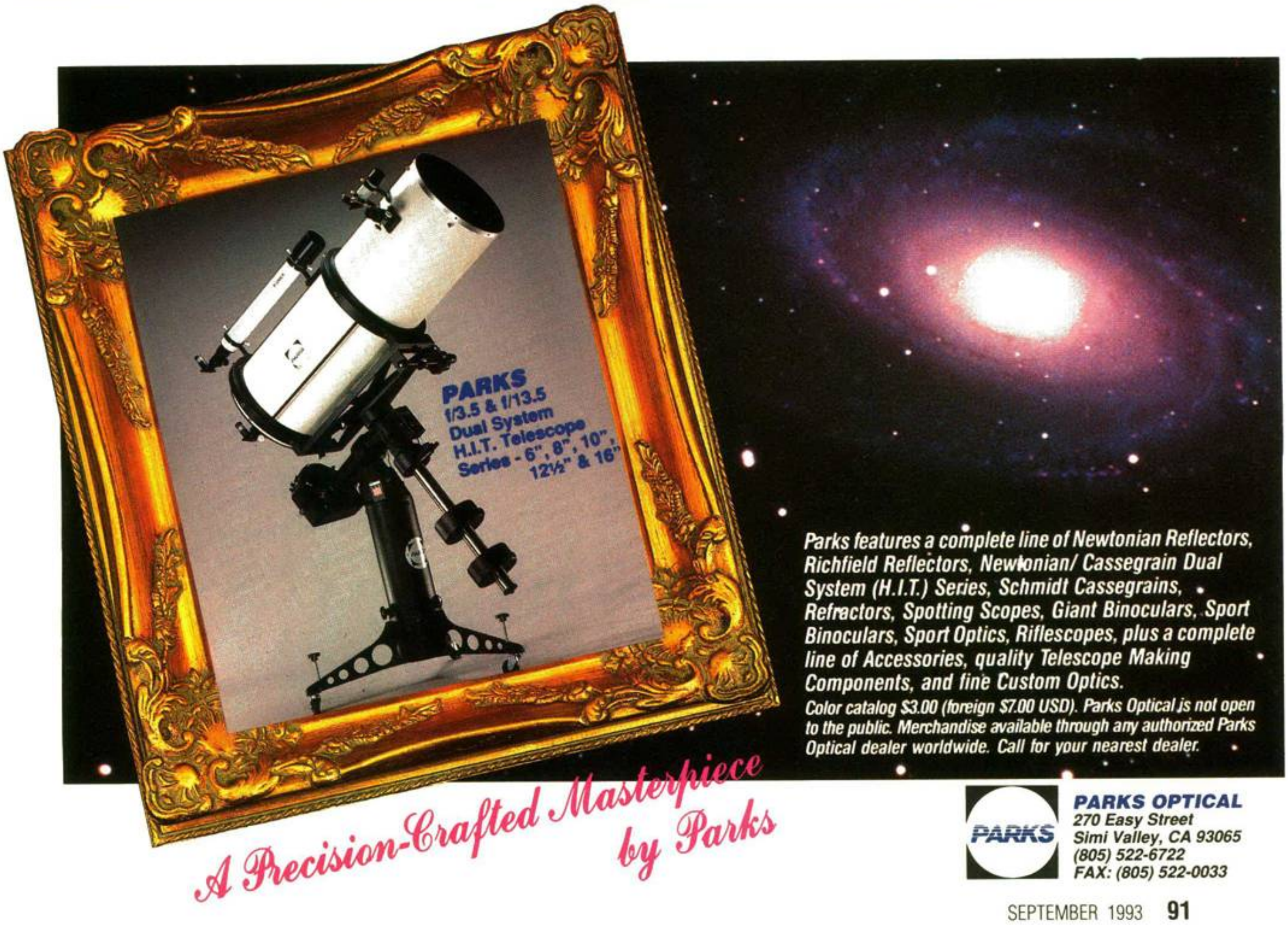

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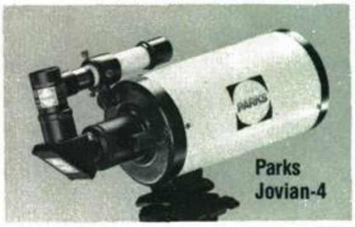

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HOW WE LEARNED ABOUT THE MOON

To a Rocky Moon: A Geologist's History of Lunar Exploration, by Don E. Wilhelms, (University of Arizona Press, 1993), ISBN 0-8165-1065-2, 479 pages, acid-free paper, sewn binding, hardcover, $29.95.

Every Moon-buff will love this book. And you don't have to know norite from troctolite to enjoy it immensely. Don Wilhelms has written a marvelous history of the most extraordinary exploration ever.

He didn't title the book *What We Learned About the Moon and How,* but he might as well have. The story starts at the turn of the 20th century (with geologist Grove Karl Gilbert and his studies of Meteor Crater) and runs up to 1984, when lunar scientists converged on the current best theory for the origin of the Moon.

Wilhelms is an ideal author for the subject. He coordinated lunar geological mapping in the Astrogeology Branch of the U. S. Geological Survey (USGS) and worked on the Lunar Orbiter missions. He trained Moon-bound Apollo astronauts, helped choose their landing sites, and debriefed them when they returned. In 1987 he authored the now-standard history of the Moon, a fine book buried in the Professional Papers series of the USGS, where it remains invisible to non-specialists. (*The Geologic History of the Moon,* USGS Prof. Paper 1348; 327 pages, hundreds of photos, $35; write USGS Books Section, Federal Center, Box 25424, Denver, CO 80225. All Moon-aficionados: get your copy before it goes out of print.)

Although *To a Rocky Moon* naturally focuses on people, you will still come away with a clear sense of lunar history. You'll also appreciate more fully the efforts that went into the Apollo program, whether by engineers, scientists, or astronauts.

I suspect Wilhelms' greatest contribution was in getting fellow scientists to "think big." Many would-be lunar geologists fell into the trap of focusing narrowly on this or that special feature. Seizing upon some oddly shaped crater or rille, they would use it to exemplify the geology of the entire Moon. Wilhelms, however, insisted that USGS mappers work with complete regions and not just individual features, however intriguing. The shift in emphasis was critically important. When scientists had to explain ordinary features before they tackled exotic special cases, they couldn't help but develop a coherent global picture.

At the end Wilhelms offers a careful assessment of what Apollo did and voices considerable regret that it was truncated early. But had Apollos 18, 19, and 20 actually flown as planned, Wilhelms would not have prolonged the series much beyond them. Apollo had done most of what it was intended to, he says, and it was time for new ideas and new techniques.

To a Rocky Moon closes with a memorable summary of the Moon's history, squeezing its 4.5 billion years into 45 minutes. Like the rest of the book, it's you-are-there writing at its best. — *Robert Burnham*

Space

Space Almanac, second edition, edited by Anthony R. Curtis, (Gulf Publishing Company, 1992), ISBN 0-88415-030-5, 746 pages, softcover, $24.95; ISBN 0-88415-039-9, hardcover, $36.95.

This fact-filled book includes information about astronauts, cosmonauts, rockets, satellites, shuttles, space stations, the solar system, and astronomical objects. Individual sections include information about space food, NASA acronyms, power stations in space, NASA's shuttle numbering system, and a calendar listing what space events happened on each day of the year. Curtis describes shuttle launches through STS-48 (September 12-18, 1991) and includes a tentative manifest through September 1994.

Children's Books

The Universe Is My Home, by Bill and Sally Fletcher, (Science and Art Publishing, 1993), ISBN 0-9634622-0-2, 32 pages, hardcover, $14.95.

Noted astrophotographers Bill and Sally Fletcher take you on an adventure through our Galaxy. They combine their own astrophotographs with NASA images and computer art to illustrate the journey of Sarah and Robert as they visit a planet around a distant star.

Other Books Received

MEPCO '92, edited by Daniel Fischer, (Im Kottsiefen 10, W-5330 Königswinter 41, Germany), 140 pages, softcover, $6 (DM 10) plus shipping. Proceedings of the first meeting of the European Planetary and Cometary Observers. ☐

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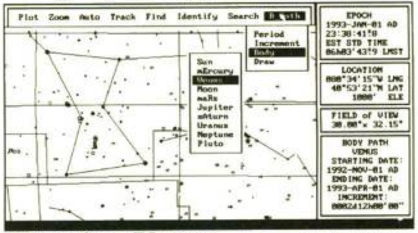

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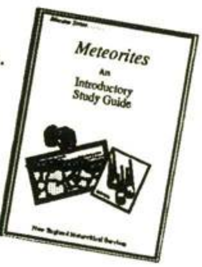

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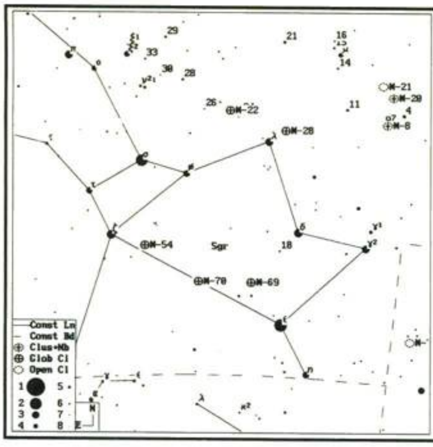

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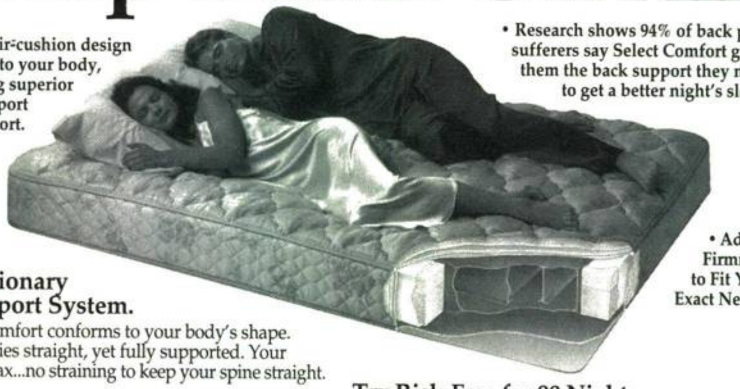

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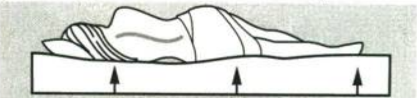

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Annual Meeting, Theodore Roosevelt National Park, North Dakota. Sponsored by the Dakota Astronomical Society. Contact: Greg M. Gramza, 757 Munich Drive, Bismarck, ND 58504. Phone (701) 223-2117.

August 19-22
Oregon Star Party, Ochoco Mountains, Oregon. Sponsored by the Rose City Astronomers and the Oregon Museum of Science and Industry. Contact: Chuck Detloff, P.O. Box 91416, Portland, OR 97291-0416. Phone (503) 629-2145.

August 20-22
Summer Seminar, Tully, New York. Sponsored by the Syracuse Astronomical Society. Contact: Joe Italiano, 1115 E. Colvin Street, Syracuse, NY 13210. Phone (315) 475-7032.

September 10-12
Astrofest, Camp Shaw-Waw-Nas-See, Kankakee, Illinois. Sponsored by the Chicago Astronomical Society. Write to Astrofest, P.O. Box 596, Tinley Park, IL 60477. Phone (708) 966-6214.

September 11
ACA/OTAA Swap Meet and Star Gaze, Portage Lakes State Park, Ohio. Hosted by the Astronomy Club of Akron. Contact: Randy Leeson, 2080 Liberty Road, Stow, OH 44224.

September 11
Lone Star Astrofest, Pate Museum of Transportation, southwest of Fort Worth, Texas. Sponsored by the Fort Worth Astronomical Society. Contact: Don Garland, P.O. Box 330445, Fort Worth, TX 76163-0445. Phone (817) 732-1631.

September 17-18
7th Annual Dark Sky, Cathedral Gorge State Park, Nevada. Write to Las Vegas Astronomical Society, G.W. Hotels, 401 South Casino Center Boulevard, Las Vegas, NV 89101. Phone (800) 634-6635.

September 17-18
Blackwater Falls Astronomy Weekend, Blackwater Falls State Park, West Virginia. Contact: Rich Ireland, Kanawha Valley Astronomical Society, Sunrise Children's Museum, 746 Myrtle Road, Charleston, WV 25314. Phone (304) 344-9620.

September 17-18
The East Coast Star Party, Coinjock, North Carolina, near the Virginia border. Contact: Kent Blackwell, 1169 Old

Kempsville Road, Virginia Beach, VA 23464. Phone (804) 495-4461.

September 17-19
Connecticut Star Party, Camp Bobriwka, Colebrook. Contact: Linda Marks, Astronomical Society of New Haven, P.O. Box 3005, New Haven, CT 06515. Phone (203) 874-4816.

September 17-19
Outside Con 6, Montgomery Bell State Park, Dickson, Tennessee. Contact: Bob Embler, Box 835, St. Bethleham, TN 37155. Phone (615) 552-2130.

September 17-19
Third Annual Huronia Star Party, Lisle, Ontario. Sponsored by the South Simcoe Amateur Astronomers. Contact: Henri von Bemmel, RR1, Colgan, ON L0G 1G0, Canada. Phone (416) 481-9937.

September 18
Blue Ridge Parkway Regional Stargaze (Part 1), Julian Price Park, North Carolina. Contact: Greg Kirby, Route 3, Box 472, Granite Falls, NC 28630. Phone (704) 396-7656.

September 18
Ohio Turnpike Astronomers Association Convention, Strawberry Mountain, Birmingham, Ohio. Contact: Michael Harkey, Black River Astronomical Society, 1631 Maple Drive, Lorain, OH 44052. Phone (216) 288-8556.

September 18
Three Rivers AstroFest '93, Frick Park, Pennsylvania. Sponsored by the Amateur Astronomers Association of Pittsburgh. Write to Wagman Observatory, P.O. Box 314, Glenshaw, PA 15116. Phone (412) 224-2510.

September 18-19
Nightfall, Borrego Springs, California. Write to NIghtfall, c/o Fox & Stephens, CPAs, 9045 Haven Avenue, Suite 109, Rancho Cucamonga, CA 91730.

September 23-26
International Meteor Conference, Puimichel, France. Organized by the International Meteor Organization. Contact: Paul Roggemans, Pijnboomstraat 25, B-2800 Mechelen, Belgium. ☐

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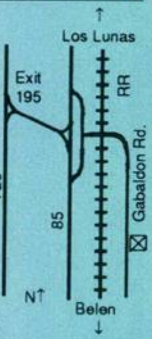

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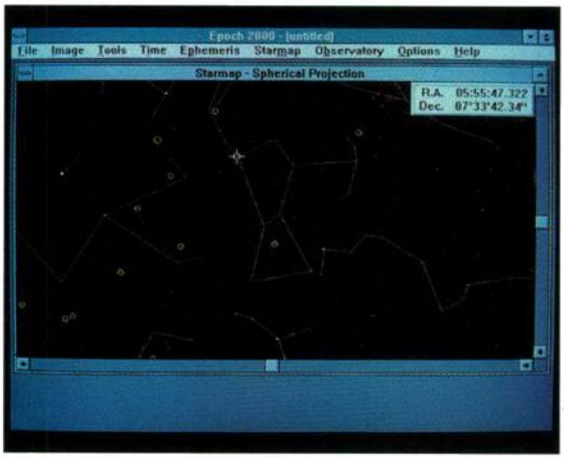
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***Epoch 2000 (1.04)**, Farpoint Research, 10932 Hasty Avenue, Downey, CA 90241-4026. Phone: (310) 861-6606. Price: $329. Minimum requirements: 80286-based computer, 640 KB of memory, DOS 3.0, Windows 3.X, EGA display, and a hard drive with 5 MB free (12 MB needed for magnitude 8.0 stellar database). A mouse, SVGA display, 80386-based computer with coprocessor and 4 MB of memory are recommended.*

Epoch 2000 is an observatory program that will point telescopes, run CCD cameras, and perform image processing. It can control Santa Barbara Instrument Group's ST-6 CCD camera, Meade's LX200 telescope, and a network of remotely controlled telescopes that is under development. (We did not test the program with either an ST-6 or LX200.)

Image processing is easy with this package, although you'll want a fast computer (80486 based) to really take advantage of it. The program will open images in the following formats: TIFF, FITS, BMP, LNX, ST4, ST6, and raw camera format (08B). It saves only TIFF, FITS, and BMP files. You can scale images in four different ways and then sharpen and edge-enhance. You can also merge separate red, blue, and green images to form tricolor images. Crop, resize, rotate, and flip functions customize your images for presentation. A click of the mouse also lets you measure the brightness of objects in an image.

To assist you in pointing your telescope, Epoch 2000 provides a star map. It plots over 45,000 stars down to 8th magnitude, more than 13,000 deep-sky objects (including the Messier, NGC, and IC catalogs), 7,500 minor planets, and over 100 comets. You can add objects to these databases and use the Hubble Guide Star Catalog (if you have a CD-ROM drive; the catalog is available separately).

The star maps provide either a spherical or azimuthal-equidistant view. (Horizon and Mercator maps would be a welcome addition.) As in most star-mapping programs, you can choose which objects to plot, add names to certain objects, turn on constellation lines, and set magnitude limits. An animation or time-step feature allows you to watch planet, comet, and asteroid paths. And a search feature makes finding stars, planets, constellations, and deep-sky objects easy.

For nighttime use, you can use the Night Vision mode that turns the screen into shades of red. One note of caution though, you need to set the image processing screen colors to red separately.

The ephemeris routines that calculate the positions of the planets are quite accurate, performing well even for Pluto. You can select three levels of precision so you can get fast or more accurate results, depending upon your needs. Epoch 2000 will calculate positions for any date between 4713 B.C. to A.D. 10,000. You can set your location to the positions of 29 observatories or a large number of cities worldwide, or you can enter your latitude and longitude. The time display shows universal, local solar, local mean solar, and local sidereal times, as well as Gregorian or Julian calendar dates.

Epoch 2000 provides a solid suite of programs that will make observing easier. Pointing the telescope is as simple as a mouse click in the star map program. You can expose a CCD image with a couple more mouse clicks and then process your image without ever leaving the main program. While you may want other astronomy programs to plot eclipse paths or to process a batch of CCD images, Epoch 2000 provides everything you need for remote observing with your home observatory. — *Dave Bruning*

Readings & Credits

Did Mars Once Have Martians?
(page 26)

"The Cosmic Origins of Life on Earth" by Christopher Chyba, ASTRONOMY, November 1992. Discusses the possibility that life on Earth developed from organic molecules brought here by asteroids, comets, and meteorites.

Mars: The Story of the Red Planet, by Peter Cattermole, (Chapman & Hall, 1992). Loaded with spacecraft imagery and USGS maps, this book is a comprehensive account of Mars in all its varied aspects with emphasis on the nature and evolution of the surface.

What Puts the Spiral in Spiral Galaxies?
(page 34)

Galaxies, by Timothy Ferris, (Stewart, Tabori, and Chang, 1982). A wonderful, picture-rich book about galaxies, including descriptions of their various shapes.

Ptolemaeus and the Straight Wall
(page 58)

Atlas of the Moon, by Antonín Rükl, edited by T. W. Rackham, (Aventinum and Kalmbach Publishing, 1990). An authoritative atlas with detailed maps. Includes information on the motion, rotation, illumination, and origin and evolution of the Moon. Intended for the beginner and recommended for most amateur lunar observers.

The Moon: An Observing Guide for Backyard Telescopes, by Michael T. Kitt, (Kalmbach Publishing, 1992). A friendly guide to the main features visible on the lunar surface through a small telescope.

Exploring the South Polar Stars
(page 68)

Observing the Constellations, by John Sanford, (Simon & Schuster, 1989). A colorful guide to observing all 88 constellations. Includes mythological information for each group.

Seeking the Best 35mm Camera
(page 74)

"Getting the Exposure Right," by Alan Dyer, ASTRONOMY, September 1992. Basic information on estimating exposures for astrophotography.

"Selecting the Right Slide Film," by Alan Dyer, ASTRONOMY, October, 1992. A comparison test of two dozen slide films for astrophotography.

"Taking Pictures with Your Telescope," by Alan Dyer, ASTRONOMY, December 1992. How to attach your camera to a telescope.

Cover: ©1977 Anglo-Australian Telescope Board; ***p. 4:*** Luke Dodd, 300mm f/4 lens, hypered Fuji 400 film, 30-minute exposure; ***p. 18:*** Jane Luu, University of California, Berkeley; ***p. 19, top:*** Bradley Whitmore (STScI) and NASA; ***bottom:*** Joel Bregman and Eric Schulmanl; ***p. 20:*** Pennsylvania State University and NOAO; ***p. 22, top:*** Steward Observatory; ***bottom left:*** Todd Small, Caltech; ***bottom right:*** Peter Conti, University of Colorado/NASA/ESA; ***p. 24:*** David J. Eicher; ***pp. 26-27:*** Paul Hudson; ***p. 28:*** NASA; ***p. 29:*** R. Vestal; ***pp. 30-31:*** Lee Vande Visse; ***pp. 32-33:*** Paul Hudson; ***pp. 34-35:*** © Anglo-Australian Telescope Board; ***p. 36, left:*** Debra and Bruce Elmegreen; ***right:*** Canada-France-Hawaii Telescope; ***p. 37, left:*** Tony and Daphne Hallas; ***right:*** Debra and Bruce Elmegreen; ***pp. 38-39:*** Debra and Bruce Elmegreen; ***p. 40:*** Chris Becker and Darla Gawelski; ***p. 41:*** Jeff Lockwood; ***p. 42, top:*** Mike DiVittorio; ***bottom:*** U. S. Geological Survey; ***p. 44, top:*** University of Toledo, SPICA; ***bottom:*** Laurence Marschall; ***p. 45:*** Robert Ashford; ***p. 48:*** Vincent Genna; ***p. 51:*** Gary Holland; ***p. 53:*** Dan Schecter; ***p. 59:*** Lee C. Coombs; ***pp. 62-67, equipment photos:*** Darla Gawelski; ***p. 66, top:*** Alan Dyer, 155EDT refractor at f/7.1, 45 minutes, Scotchchrome 400 pushed to ISO 800; ***bottom:*** Alan Dyer, 105EDT refractor with Astro-Physics Telecompressor at f/4.4, 15 minutes, Scotchchrome 400 pushed to ISO 800, taken from Las Campanas, Chile; ***p. 68:*** Terence Dickinson, 20mm lens; ***p. 69:*** Chris Floyd, 10-inch f/4.5 Newtonian; ***pp. 70-71:*** Steven G. Davis; ***p. 72, top:*** Jim Barclay, 12-inch telescope, ISO 1600 film, 20-minute exposure; ***bottom:*** Alan Dyer, 105EDT refractor at f/4.4, 20 minutes, Scotchchrome 400 pushed to ISO 800; ***p. 73:*** Jack Marling, 24-inch f/7.5 telescope, Fujichrome RD100 film, 50-minute exposure; ***p. 74:*** Terence Dickinson, 85mm lens at f/1.7, 2 minutes, Scotchchrome 400 pushed to ISO 800; ***pp. 74-79, equipment photos:*** Darla Gawelski; ***pp. 74-79, astrophotos***: Alan Dyer, all on Ektachrome 400X; ***p. 81, top:*** Bill and Sally Fletcher, 16-inch f/4.5 reflector, tricolor image using hypersensitized Tech Pan film and three filtered 90-minute exposures on April 25, 1993; ***center:*** Gary A. Fouts, 16-inch f/4.5 reflector, SBIG ST-4 CCD camera, 40-second exposure on April 19, 1993; ***bottom:*** Don Trombino, 6-inch refractor at f/32, Tech Pan film, 1/125-second exposure using a DayStar hydrogen-alpha filter on March 12, 1993; ***p. 82, top left:*** Luke Dodd, 300mm lens at f/4, hypersensitized Fuji 400 film, 20-minute exposure; ***bottom:*** Jack Newton, 25-inch reflector, SBIG ST-6 CCD camera, image processed using Hidden Image; ***pp. 82-83:*** Gary Jones and Mike Warnell, 7-inch refractor, hypersensitized Tech Pan film; ***p. 83, bottom:*** Bill and Sally Fletcher, 35mm lens at f/3.5, Ektar 100 film, 1-second exposure on March 9, 1993; ***p. 100:*** Darla Gawelski.

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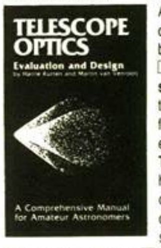

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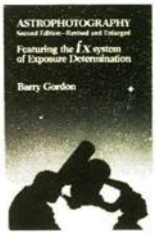
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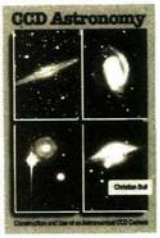

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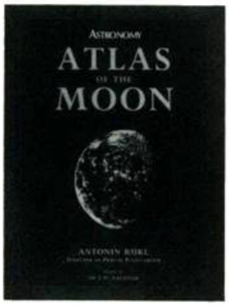

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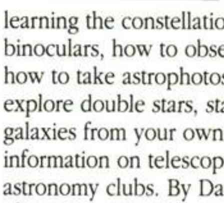
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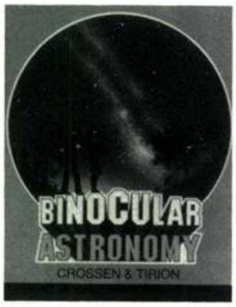

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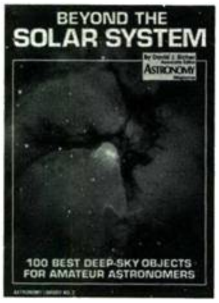

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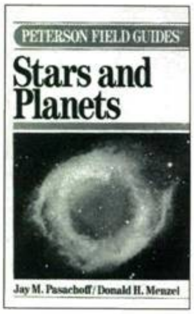

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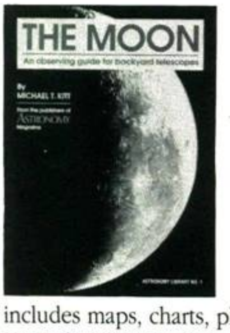

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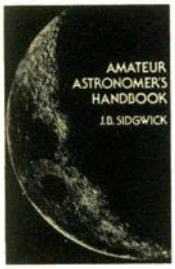

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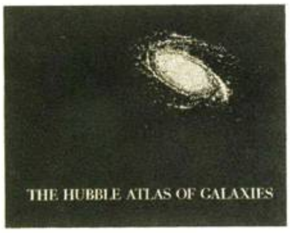

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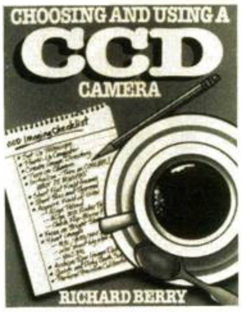

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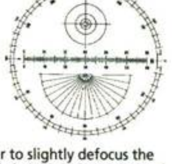

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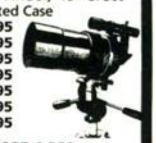

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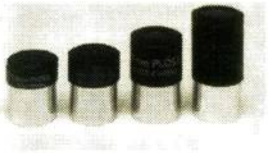

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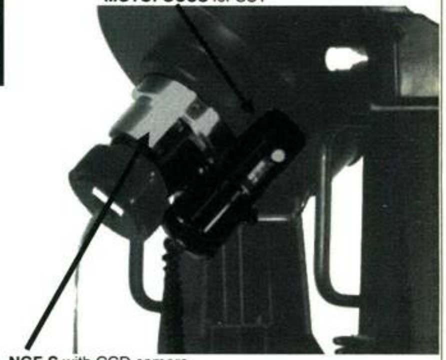

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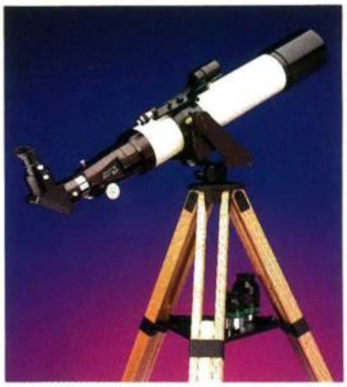

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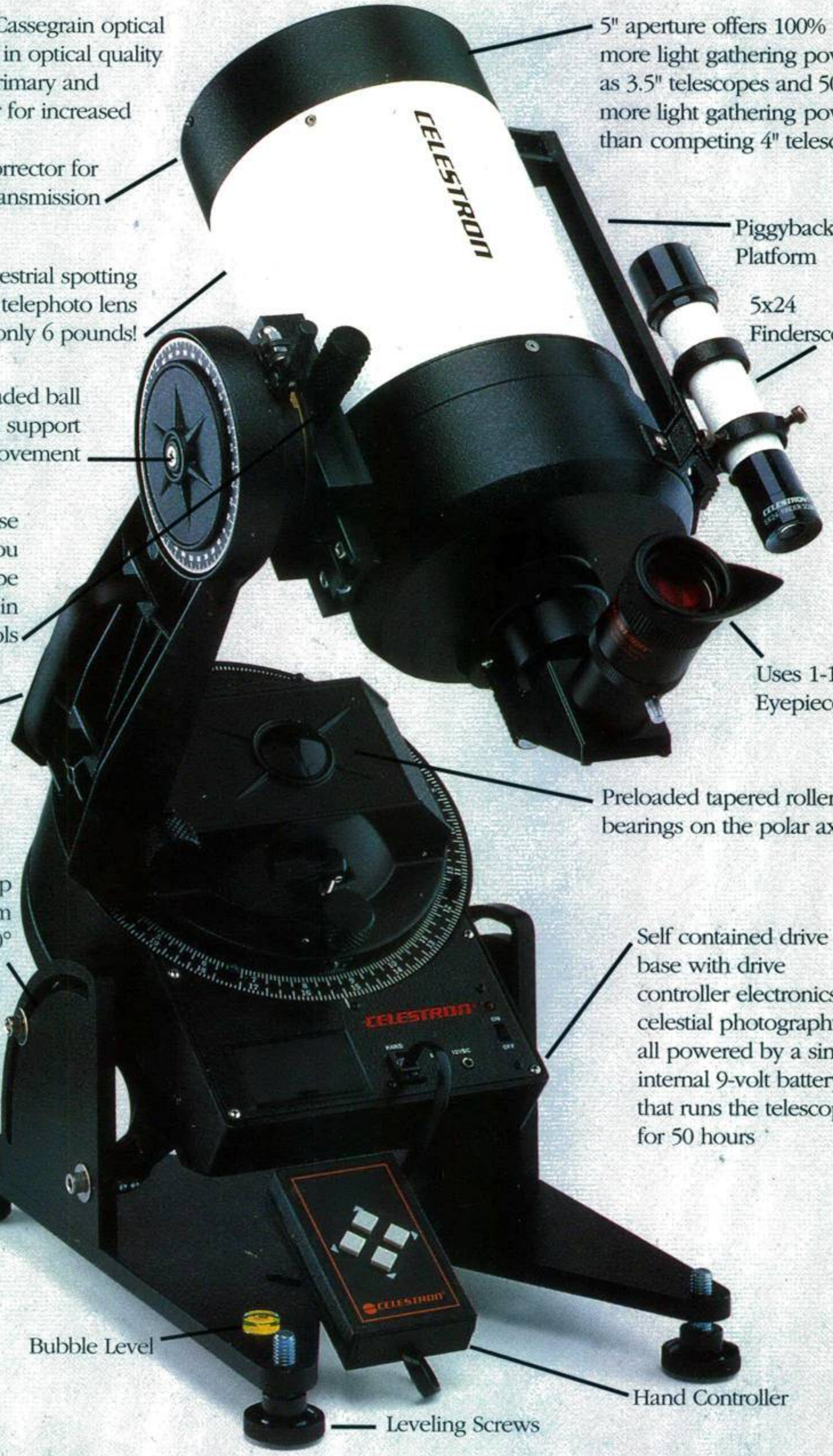

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